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**Fast-Track Environmental Cleanup:  
A NAS Alameda-University of California Partnership  
Contract Number: N62474-94-D-7420**

**DELIVERY ORDER 003**

**PILOT-SCALE TREATABILITY WORK PLAN**

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REVISION 1

PILOT-SCALE TREATABILITY WORK PLAN  
STEAM ENHANCED EXTRACTION – SITE 13

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## 1. INTRODUCTION

This Work Plan is written to specify the design, implementation, and operation of a pilot-scale treatability study of Steam Enhanced Extraction (SEE) at Site 13, Abandoned Oil Refinery, at NAS Alameda. Based on previous investigations at Site 13, oily waste is found in high concentrations below the four-foot deep water table. *In situ* restoration options for remediation include biosparging, where air would be injected into the oil bearing zones to stimulate biodegradation, and both bioventing and soil-vapor extraction during dewatering. However, these ambient-temperature technologies cannot be expected to recover the viscous hydrocarbon phase to a significant extent, and would be inherently slow due to low volatilities, aqueous-phase diffusivities, solubilities, and vapor pressures of the contaminants.

Because the waste oil will become more volatile, less dense and flow more readily as the boiling point of water is approached, applicable temperature-enhanced *in situ* technologies are of interest to the acceleration of remedial processes. The mechanisms exploited by thermal processes are the reduction of the oil viscosity and oil-water interfacial tension to increase mobility, an increase in the difference between the water and oil densities to increase the upward flow driving force, and an increase in the hydrocarbon mixture vapor pressure to enhance its evaporation rate. Thus, thermal processes are expected to be the most rapid of the viable options. An effective process would include significant free product pumping and removal of the more volatile and soluble components of the immobile hydrocarbon mixture to minimize potential for future exposure. Applicable thermal heating processes include steam injection and electrical heating. The assessment of feasible *in situ* technologies is required prior to a regulatory Record of Decision; this will require the evaluation of thermal remediation techniques.

Given the readily available clean steam source from facility steam plants, SEE appears to be particularly attractive for pilot-scale testing at Site 13. There are no structures on the site that would interfere with application of SEE, and there are no immediate planned uses of Site 13.

The project consists of a laboratory treatability study and field scale tests, first with three wells over a period of 30 days, followed by a pilot-scale test with 15 wells run for an additional 180 days. The pilot-scale demonstration of SEE at Site 13 is to follow this Work Plan, unless new data suggests better design, implementation procedures or data collection protocols.

## 1.1 OBJECTIVES

The overall objective of this project is to ascertain the viability of the SEE process as a cost-effective *in situ* remedial method for restoration of soils and groundwater containing the low-volatility hydrocarbons at Site 13. Laboratory treatability test objectives are to determine the rates and extents of toxic substance removal by SEE. Specific objectives of the three well treatability tests are to quantify *in situ* hydraulic parameters, assess the performance of the prototype injection/extraction well design, and identify potential operational difficulties in above ground fluid treatment. The pilot-scale test objective is to provide a comprehensive assessment of the overall technical feasibility of the process to restore the site and identify any improvements in the design and implementation of the process if expanded to full-scale site cleanup.

## 1.2 BACKGROUND OF SEE PROCESS

SEE was developed in the late 1980s by engineering scientists from the University of California at Berkeley. While steam injection for enhanced oil recovery has been practiced for decades by the oil industry, additional thermodynamic features of the process were identified and exploited in the Berkeley work to make the process amenable to the restoration of sites contaminated with volatile and semi-volatile liquid contaminants found above and below the water table, as well as non-volatile compounds in the aqueous phase.

The SEE process removes hydrocarbons from the soil by injecting steam to volatilize hydrocarbons present in the subsurface. Hot vapors which contain the volatilized hydrocarbons are captured, condensed, contained, and treated to remove hydrocarbons. At Site 13, the process will include:

- Warming the treatment zone with steam to mobilize free product to the top of the water table where it will be pumped from the subsurface;
- Collection and disposal of recovered free product;
- Dewatering to expose residual oil to injected steam and to enhance volatilization;
- Collection of condensate from extraction wells and from the ground surface;
- Treatment of the condensate by carbon adsorption followed by discharge to the sanitary sewer; and

- Injection of air or pure oxygen into the hot, dewatered oil bearing zone to dry the soil and oxidize the heavier oil fractions.

### **1.3 PARTNERSHIP AGREEMENT**

On August 24, 1994, the U.S. Navy and the University of California entered into a partnership that provides the framework for exploring the application of innovative environmental restoration technologies developed by the University of California at Berkeley (UCB), the Lawrence Livermore National Laboratory (LLNL) and the Lawrence Berkeley Laboratory (LBL), on Installation Restoration (IR) sites NAS Alameda. This partnership is governed by Contract No. N62474-94-7420.

Delivery Order (DO) 003 funds the demonstration of the SEE technology at Site 13 for the removal of contaminants from the soils and groundwater. UCB shall perform the following tasks in order to accomplish this objective:

- 1) Prepare a Work Plan to install treatability and pilot-scale test wells.
- 2) Install, operate, and monitor the treatability test wells to determine if the soil characteristics favor further application of the SEE technology in a pilot-scale process.
- 3) Prepare a report commenting on the treatability test results.
- 4) Install, operate, and monitor the pilot-scale SEE process in the field to determine further application of the SEE technology in a full-scale process.
- 5) Prepare a report on the pilot-scale results of the SEE technology.
- 6) Produce 75 percent designs for full scale operation of the SEE process.

This Work Plan is written in response to the requirements of Task One and describes Tasks Two through Six.

### **1.4 RELATED DOCUMENTS**

As part of their partnership agreement with EFA West, the Berkeley Environmental Restoration Center (BERC) will implement innovative restoration technologies at three sites within NAS Alameda, including Site 13. The following two documents have been prepared to describe general quality assurance/quality control and health and safety procedures to be followed for each site:

- Contractor Quality Control Program Plan, Revision A, dated June 1995, prepared by E2; and
- Health and Safety Plan, Volumes I and II dated June 8, 1995, prepared by BEREC.

Work conducted at Site 13 will be conducted in accordance with the general procedures described in these program level documents as well as Standard Operating Procedures and Standard Quality Procedures that are being prepared for this project. This Work Plan describes site-specific procedures to be followed.

## 1.5 ORGANIZATION OF WORK PLAN

Section 1 of this work plan presents an overview of the pilot-scale treatability study to be performed at Site 13, as well as the contracting mechanisms that authorize the work and related documents that need to be referred to during implementation of the study. A brief background of NAS Alameda and Site 13 are presented in Section 2 with a discussion of previous investigations. The site hydrogeology is described in Section 3. Soil and groundwater quality are described in Section 4 and probable exposure pathways are presented in Section 5. Data gaps are described in Section 6. Section 7 presents the treatability testing that needs to be conducted in support of the pilot-scale study. The design of the field-scale study is presented in Section 8. An implementation plan, including the sampling and analysis plan, is included in Section 9. The project organization is described in Section 10.

Detailed results of a laboratory shake-down treatability experiment will be included in Appendix A when data are available. Appendix B includes the Contractor Quality Control Plan (CQCP); Appendix C contains the Site Health and Safety Plan (SHSP); Appendix D contains the Environmental Protection Plan (EPP) for the pilot-scale treatability study. The piping and instrumentation diagram (P&ID) is included in Appendix E.

Supplemental information is included in Appendix F. This information includes Standard Operating Procedures (SOPs) that will be implemented as a part of the sampling and analysis plan. These SOPs are draft and will be issued as final at a later date.



## **2. BACKGROUND**

### **2.1 NAS ALAMEDA DESCRIPTION**

NAS Alameda is located on the western end of Alameda Island. The base, rectangular in shape, is approximately 2 miles long and 1 mile wide, and occupies 2,634 acres. Approximately 1,526 acres of NAS Alameda are land and 1,108 acres are bay.

Much of the land now occupied by NAS Alameda was once covered by the waters of San Francisco Bay or was tidal flats. Much of the base was gradually filled using hydraulically placed dredge spoils from the surrounding San Francisco Bay, the Seaplane Lagoon at NAS Alameda, and the Oakland Channel (PRC, 1994).

The Army acquired the NAS Alameda site from the city of Alameda in 1930 and began construction activities in 1931. The Navy acquired title to the land from the Army in 1936 and began building the air station in response to the military buildup in Europe prior to World War II. After the 1941 entry of the United States into the war, more land was acquired adjacent to the air station. Following the end of the war, NAS Alameda returned to its original primary mission of providing facilities and support for fleet aviation activities.

### **2.2 SITE 13 HISTORY**

The following history of Site 13 was obtained from Naval Air Station, Alameda, Alameda, California, Remedial Investigation/Feasibility Study Site Conceptual Models, Preliminary Draft dated September 22, 1994, and prepared by PRC Environmental Management, Inc. (PRC) and Montgomery Watson (PRC, 1994b). Site 13 consists of approximately 30 acres located in the southeast corner of NAS Alameda. This site is the former location of the Pacific Coast Oil Works refinery, which operated between 1879 and 1903. Refinery wastes and asphaltene residues were dumped at the site during the 24-year history of the refinery. The refinery consisted of pump and lubricating houses, stills, two laboratories and agitators, as well as approximately 19 above-ground iron oil storage tanks, six underground iron storage tanks, and a storage area containing drums of oil.

The area once occupied by the refinery was later surfaced by the Navy. Sometime in the 1940s, a surface rupture occurred as a result of vapor pressure buildup from underground hydrocarbons and refinery wastes. The Navy excavated an area of approximately 30 by 30 feet (depth not recorded), and a concrete slab was emplaced in the bottom of the excavation which was then backfilled and resurfaced.

Several naval facilities now exist on the site of the former oil refinery. A former on-base annex service station, Building 547, is located in the northeast corner of the former oil refinery area. In the northwest corner is a hazardous waste storage yard, which is currently in operation. A missile rework facility is housed in Building 530, which is located in the southern portion of the former oil refinery area.

During a previous removal action, approximately 104 cubic yards of soil exhibiting a low pH and containing high lead concentrations was removed. Approximately another 50 cubic yards was expected to be removed after September 1994. For this removal action, soil containing lead at concentrations greater than 100 mg/kg were removed from the southern portion of Site 13.

In February 1991, a JP-5 release occurred on the east side of Building 397, a jet engine test cell. Following a period of heavy rains, several storm drain manholes overflowed, resulting in an accumulation of free product; twelve manholes in the area were found to contain floating product. The storm drain lines south of Building 397 were reportedly extensively damaged during the 1989 Loma Prieta earthquake and groundwater in the area may have been impacted by JP-5 leaking from the damaged storm sewer lines.

## 2.3 PREVIOUS INVESTIGATIONS

Remedial investigations have been conducted at numerous IR sites throughout NAS Alameda. The reports which document these investigations include the following which were prepared by PRC and Montgomery Watson:

- NAS Alameda, Alameda, California, Data Summary Report RI/FS Phases 1 and 2A, Final. August 25, 1993.
- NAS Alameda, Alameda, California, Data Summary Report RI/FS Phases 2B and 3, Final. October 27, 1992.
- NAS Alameda, Alameda, California, Solid Wastewater Quality Assessment Test (SWAT) and Data Summary Report RI/FS Phases 5 and 6, Final. April 30, 1993.

As part of the remedial investigation(s) at Site 13, six groundwater monitoring wells (MW-1 and MWOR-1 through MWOR-5) and 22 soil borings (BOR-6 through BOR-27) have been installed at Site 13 (PRC, 1994). Soil and groundwater samples from these monitoring wells and borings have been laboratory analyzed.

A conceptual model of Site 13 presenting a summary of existing analytical data and an assessment of exposure pathways is also included in Naval Air Station, Alameda, Alameda, California, Remedial Investigation/Feasibility Study Site Conceptual Models, Preliminary Draft dated September 22, 1994. This report was also prepared by PRC and Montgomery Watson.

In March and April 1994, PRC conducted a Site Characterization and Analysis Penetrometer System (SCAPS) project at Site 13. The SCAPS project included the advancement of 45 SCAPS push holes (ALA13P1 through ALA13P45) and eight hollow stem auger borings (ALA13B38 through ALA13B45). The results of the project are described in SCAPS Push and Intercalibration/Validation Boring Summary Report, Naval Air Station Alameda - Site 13, Old Refinery Site, Alameda, California dated August 19, 1994 and prepared by PRC. As part of this project petroleum hydrocarbon concentrations in the soil were measured using an in-situ fluorometer. The results of these measurements were validated by traditional laboratory analysis of selected soil samples for total recoverable petroleum hydrocarbons (TRPH), and total petroleum hydrocarbons as diesel, gasoline, JP5 and motor oil (TPHd, TPHg, TPHjp5, and TPHmo).

### 3. SITE HYDROGEOLOGY

Soils encountered during implementation of the SCAPS project include hydraulically placed fill and Young Bay Mud Deposits (PRC, 1994a). The hydraulically placed fill consists primarily of sand and silty sand. In places, these materials are mixed with refinery wastes described as a black, tar-like material. The fill is underlain by Young Bay Mud Deposits consisting of sand, silt, and clay. The depth to groundwater at Site 13 ranges from 5.94 to 6.04 feet below ground surface (bgs) (PRC, 1994c).

### 4. DISCUSSION OF SOIL AND GROUNDWATER QUALITY

Soil and groundwater samples have been collected as part of the remedial investigation(s) and SCAPS project at Site 13. Based on the results of the remedial investigations, the pH of soil samples from Site 13 ranges from 6.2 to 10 and total organic carbon concentrations range from 109 to 16,800 mg/kg (PRC, 1994 b). The following chemicals have been identified in the near surface soil and at depths up to 15 feet bgs:

- TRPH; benzene, toluene, ethylbenzene, and xylenes (BTEX); n-nitroso-diphenylamine; butylbenzylphthalate; polynuclear aromatic hydrocarbons (PAHs); and the pesticides beta-BHC, heptachlor epoxide, 4,4-DDT, 4,4-DDE, 4,4-DDD, and toxaphene.

Total dissolved solids concentrations in groundwater samples ranged from 620 to 3,160 mg/l; total organic concentrations ranged from 7.5 to 57.6 mg/l; dissolved oxygen concentrations ranged from 1.6 to 6.2 mg/l; the pH ranged from 6.7 to 7.8; and the specific conductivity ranged from 470 to 4,020 cm (PRC, 1994b). The following chemicals have been identified in the groundwater at Site 13:

- TRPH, benzene, ethylbenzene, xylenes, 4,4-DDT, PAHs, and metals.

Sediments in the storm drains had not been sampled in September 1994 and are not of concern for this pilot-scale test.

The results of the SCAPS project identified the following zones of contamination (PRC, 1994a):

- Refinery wastes present in the southeast portion of the site from a depth of five to 15 feet below ground surface. The western, northern, and southern extent of refinery wastes has been identified by the SCAPS project. The eastern extent has not been identified because it intermingles with the release from the NEX service station and because this site is located near the eastern base boundary which restricts additional sampling locations to the east of those areas already sampled.
- An asphaltic and/or oily dust surface feature.
- A gasoline release from the former on-base annex service station located at Building 547. The horizontal extent of this release has not been identified.
- A release of JP-5 near Building 397 which is a jet engine test cell. The horizontal extent of this release has not been identified.

The horizontal extent of TRPH in the soil as inferred from the SCAPS project is shown on Figure 4.1, and the vertical extent is inferred on Figure 4.2.

## 5. PROBABLE TRANSPORT PATHWAYS

Potential sources of soil and groundwater contamination at Site 13 include historic oil refinery operations and wastes as well as the JP-5 release on the east

side of Building 397. Based on the exposure pathway analysis prepared by PRC (PRC, 1994b) the following transport/exposure pathways are considered currently present at Site 13:

- Volatilization of compounds identified in the soil and groundwater to outside air which would be inhaled by site occupants;
- Wind suspension of soil particulates which could result in off-site deposition of particulate on previously uncontaminated soil and could result in human exposure to the chemicals in the soil either through ingestion or direct contact. The particulates could also be inhaled by site occupants;
- Direct contact with or ingestion of soil and/or groundwater that contains chemicals.

## 6. DATA GAPS

Data gaps that will need to be addressed before the pilot-scale treatability study is performed include:

- Additional treatability testing is necessary to evaluate the effectiveness of the SEE process on soil from Site 13.
- The easterly extent of TRPH in the soil has not been fully characterized.
- The TRPH concentrations have not been fully characterized in the eastern portion of horizontal extent of TRPH inferred from the SCAPS project; and additional sampling to characterize the extent and concentration of TRPH in the soil is described in Section 9.3 along with other sampling and analysis that will be conducted during implementation of the pilot-scale study. Section 7 describes additional bench scale testing that will be performed.

## 7. LABORATORY TREATABILITY TESTS

Previous laboratory treatability tests of the applicability of SEE to relatively low volatility hydrocarbon mixtures such as JP-5 fuel and coal tars showed effective removal of those liquid compounds from soils. There are questions whether SEE would be effective in removing the waste oil from the Site 13 soils, since the oil may be from distillation column residues and may consist of non-volatile

components. The potential extent of removal of the toxic components of the waste oil from Site 13 soils by SEE, and the composition of the residual hydrocarbons are of interest. To better define the characteristics of the effluent liquids and residual waste oil, a laboratory treatability test will be conducted. The apparatus, sample preparation procedures, steam injection schedule, and soil and effluent chemical analyses for the laboratory experiment are presented below.

## 7.1 ONE-DIMENSIONAL EXPERIMENTAL APPARATUS

As shown in Figure 7.1, the apparatus for the one-dimensional treatability experiment consists of a pair of metering pumps to deliver a constant mass flow rate of distilled water, a steam generator to boil the water into steam, a stainless steel pipe to hold the contaminated soil sample, and an effluent collection jar maintained in an ice bath to minimize loss of components from the effluent to the atmosphere. The inlet and outlet of the sample holder have end caps which can be unbolted and removed to pack and unpack the soil sample. These caps have channels cut on their inner surface in contact with the soil to help spread the injected steam across the entire inlet cross section of the sample holder and reduce the end effects of the one-dimensional experiment. In addition to these channels, 300- and 25-mesh stainless steel screens are attached to the inner surfaces of the end caps to encourage uniform spreading of the steam over the sample holder cross section and to prevent the grains of soil in the sample from escaping the sample holder. The stainless steel sample holder is wrapped with heater tape and insulated. During injection, this heater tape is set to a constant supply power to offset the heat loss through the insulation, maintaining a constant temperature along the length of the tube and thus produce an adiabatic environment. Thermocouples are mounted at the steam inlet tubing, the upstream end of the soil sample, the downstream end of the soil sample, and the outlet tubing. Teflon tubing is used to carry all fluids into and out of the system. The outlet tubing is long enough to allow the effluent to cool to near room temperature before it enters the effluent collection bottle. Because flow rates are low, usually one meter of tubing is a sufficient length. Not shown in the diagram is a condenser stage which can be added to the outlet tubing between the outlet of the stainless steel piping and the effluent collection jar when the effluent flow rate is too high to condense all of the steam in the effluent tube.

## 7.2 SOIL SAMPLE PREPARATION

Soils will be taken from contaminated regions of Site 13 using a hand auger. The soil will be chilled to reduce hydrocarbon vapor pressures and mixed in a clean Pyrex tray to uniformly distribute the waste oil throughout the sample. Two samples will be sent to an outside laboratory for analysis. If the TPH concentrations of the two soils analyzed are less than 5,000 mg/kg and within 10% of each other, then the soil will be packed into the sample holder. If the samples contain hydrocarbon concentrations greater than

5,000 mg/kg, the clean fine sand similar to that of the soil samples will be mixed with the contaminated soil to reduce the concentration to 5,000 mg/kg. By reducing the concentrations to this value, the experiment can be completed in reasonable time period of the order of two weeks.

Contaminated soils will be packed into the stainless steel sample holder by alternately adding a few centimeters of soil and compacting with a large wooden dowel to reduce void spaces in the pack. The thermocouples situated within the soil will be inserted during packing. Packing will continue until enough material is in the sample holder to require slightly compressing the end cap when it is bolted into place. This compression minimizes voids created during settling of the sand pack. Such voids are undesirable since they compromise the homogeneity of the one-dimensional sand pack and could lead to uneven steam flow. To minimize the end effects, 1 inch of clean sand will be packed at the exit of the sample holder and 1.5 inches of clean sand will be packed at the inlet.

### 7.3 STEAM INJECTION PROCEDURE

After packing the sample holder with contaminated soil as described in the sample preparation section, the metering pumps will be set to provide a constant water flow rate of 38 ml/hr. Previous experiments on tarry compounds more volatile than those suspected at Site 13 show that a contaminant level of 10,000 mg/kg can be removed to a level exceeding 99% in about two weeks. Based on those results, we expect to conduct the treatability tests for two to three weeks depending on effluent fluid characteristics. If the effluent liquid has no visible liquid hydrocarbon as floating product or emulsion, and the effluent has no odor, the experiment will be concluded. The contaminant concentrations removed by steam are highest in the first part of injection, so a sampling regime will be employed that takes more frequent samples early giving a better resolution of contaminant removal during this stage. All of the effluent coming from the sample holder will be collected into sample bottles according to the following regime:

		Target Time (hrs)	Cumulative Time (hrs)
Begin Injection		0	0
Sample	1	1	1
Sample	2	1	2
Sample	3	1	3
Sample	4	1	4
Sample	5	4	8
Sample	6	4	12
Sample	7	4	16
Sample	8	4	20
Sample	9	8	28
Sample	10	8	36
Sample	11	8	44
Sample	12	8	52
Sample	13	12	64
Sample	14	12	76
Sample	15	12	88
Sample	16	12	100
Sample	17	24	124
Sample	18	24	148
Sample	19	24	172
Sample	20	24	196
Sample	21	24	220
Sample	22	24	244
Sample	23	24	268
Sample	24	24	292
Sample	25	24	316
Sample	26	24	340
Sample	27	24	364
Sample	28	24	388
Sample	29	24	412
Sample	30	24	436
Sample	31	24	460
Sample	32	24	484
Sample	33	24	508
End Injection	34	24	532

This regime provides small samples of effluent allowing detailed analysis of effluent concentrations during the first few hours of injection, and it gives large samples of effluent later in the experiment when concentrations are low and changing slowly. To minimize sample degradation, an ice bath will surround each bottle while collecting the effluent. As each bottle fills, it will be sealed with a Teflon cap and placed in a refrigerator at 4°C ( $\pm 2^\circ\text{C}$ ) or an ice bath to prepare for transport to the analytical laboratory.

The pressure in the sample holder will be cycled throughout the injection using a timer on a solenoid valve at the outlet end of the sample holder to close the outlet for one



hour and open the valve for thirty minutes while maintaining steady steam flow into the inlet. With the valve closed steam pressures should rise to about 207 kPa gauge (30 psig), then we will open the valve to depressurize the system over about two minutes. Cycling in this way first increases the pressure and temperature of contaminants in the sand pack then causes the contaminants to vaporize as the ambient pressures returned to normal. This increases the contaminant concentrations in the effluent by mobilizing contaminant trapped in less accessible regions such as crevices between sand grains. During steam cycling, the effluent tube will be placed in an ice bath to condense the effluent before it reaches the sample bottle. This is necessary because the fairly rapid depressurization of the test section produces enough steam to heat the effluent tube and send vapors to the collection bottle where they could be lost to the atmosphere from around the tube's entrance through the bottle cap.

#### **7.4 LABORATORY SAMPLE ANALYSIS PLAN**

The soil and effluent samples will be sent to a certified laboratory for chemical analysis. The soil samples taken from the site will be analyzed for TPH (EPA method 8015/5030), PAHs (EPA method 8270), metals (EPA method 6010), and pesticides (EPA Method 8080). The table below summarizes the samples to be analyzed and the methods to be employed.

#### **7.5 QUALITY ASSURANCE/QUALITY CONTROL**

The one-dimensional bench study will follow the quality assurance and quality control procedures outlined in the Quality Assurance/Quality Control Plan. In addition, all water injected into the sample holder will be distilled and then boiled to reduce the amount of dissolved gas. All tubing used to carry the water and effluent will be PTFE to lower the risk of water or effluent contamination by interaction with the tube material. During the entire experiment, the system remains closed except for the necessary introduction of water to the metering pumps and the changing of the sample bottles to minimize the chance of system contamination. All sample bottles will be prepared by washing with nonphosphate detergent followed by multiple tap water and distilled water rinses. After washing, the bottles will be oven dried and sealed with Teflon caps. The sample bottles will be kept in an ice bath while the sample is being collected to keep the effluent temperature low and minimize potential evaporation. Full sample bottles will be capped with a Teflon cap and placed in a refrigerated space or into a cooler containing ice to maintain temperatures at 4°C ( $\pm 2^\circ\text{C}$ ). Each cooler will contain a method blank consisting of a bottle prepared along with the sample bottles, filled with distilled water as used in the metering pumps, capped with a Teflon cap, and placed in the cooler along with the first effluent sample. The method blank should indicate any contamination in the preparation, storage, and transportation of the samples. All samples will be sent for analysis within the prescribed holding time. All

	TPH (Method 8015)	PAHs (Method 8270)	Metals (Method 6010)	Pesticides (Method 8080)
Original Soil #1	√	√	√	√
Original Soil #2	√	√	√	√
Post-Steam Soil #1	√	√	√	√
Post-Steam Soil #2	√	√	√	√
Post-Steam Soil #3	√	√	√	√
Effluent #1	√	√		
Effluent #2	√			
Effluent #3	√			
Effluent #4	√			
Effluent #5	√			
Effluent #6	√			
Effluent #7	√			
Effluent #8	√			
Effluent #9	√			
Effluent #10	√			
Effluent #11	√			
Effluent #12	√			
Effluent #13	√			
Effluent #14	√			
Effluent #15	√			
Effluent #16	√			
Effluent #17	√			
Effluent #18	√			
Effluent #19	√			
Effluent #20	√			
Effluent #21	√			
Effluent #22	√			
Effluent #23	√			
Effluent #24	√			
Effluent #25	√			
Effluent #26	√			
Effluent #27	√			
Effluent #28	√			
Effluent #29	√			
Effluent #30	√			
Effluent #31	√			
Effluent #32	√			
Effluent #33	√			
Effluent #34	√			

samples will be packed with foam and ice prior to transportation. Each cooler will contain a chain of custody and be sealed with custody tape.

## 8. PILOT-SCALE SEE DESIGN

The application of SEE to Site 13 would include operation to first mobilize the free product oil to the top of the water table by injection of steam from below. From there it would be pumped from the subsurface. Thereafter, significant soil dewatering would be necessary to expose the residual oil to flowing steam to enhance vaporization of the light ends. Dewatering will take place during both the treatability and pilot-scale phases. An attempt will be made to lower the water table to at least 10 feet below ground surface. Until the transmissivities of the water-bearing materials are determined, it will not be known whether dewatering to 10 feet will be possible. Injection of air or pure oxygen into the hot, de-watered, oil-bearing zone will lead to the drying of the soil, and may also lead to significant oil oxidation rates of the heavier oil fractions.

Implementation of SEE at Site 13 will require the installation of a set of wells for steam injection/fluid withdrawal, and the appropriate above-ground fluid processing equipment. In addition, a surface containment system will be installed to capture condensable vapors created during steam injection. Base steam, compressed air, water, power, and wastewater disposal utilities are available adjacent to the site. Present utility locations are shown in Figure 4.1.

Steam injection would be continuous to the site but alternate between the various wells in the pattern as needed to maintain energy levels and optimize recovery efficiency. The pilot-scale treatability study design should be similar to that of the full-scale implementation with individual well injection rates and well spacing the same as that considered for full-scale implementation. The pilot-scale study would involve the installation and operation of a much smaller number of wells than for full-scale cleanup with wells located in areas of high concentrations and extending to the edge of the contaminated region as conceptually shown in Figure 8.1.

Before the pilot-scale equipment can be properly sized and assembled, preliminary data on the subsurface permeability and prototype well design performance are necessary. Thus, three treatability study wells will be installed and operated for 30 days to gather process data appropriate for pilot-scale system final design. The initial three wells will be located to become part of the pilot-scale pattern if initial results indicate SEE applicability to site cleanup.

The three test wells will be installed at the approximate locations shown on Figure 8.2; specific locations will be selected after additional site characterization

is completed as described in Section 9.3.1. Actual locations for pilot scale test wells will be selected using the results of the three well treatability test. A high soil hydrocarbon concentration area will be targeted for the three test wells to allow significant oil volume recovery. Recent applications of SEE in similar situations showed the need for great flexibility in the control of liquid pumping operations, and steam injection locations. The design to be tested at NAS Alameda is a significant improvement in these regards. Details of the well design are shown in Figure 8.3. The design includes two screened intervals; the deeper interval is for steam injection and the upper interval is for vacuum extraction and liquid pumping. Liquids, including the hydrocarbon phase, will be removed using a gas displacement pump. Compressed air will be used as the displacement gas. For greater precision in subsurface transport definition, the design will also allow for the insertion of a logging tool used to evaluate vertical gas flow rates, gas concentrations, and temperatures.

Thirteen temperature observation wells will also be installed as shown in Figure 8.2. The design of the temperature observation wells will allow percussion insertion for reduction in cost, greater temperature sensitivity, and elimination of soil drilling disposal. Subsurface temperatures are monitored by the placement of subsurface thermocouples. To allow for the possibility of continuous temperature logging, the fixed thermocouples will be attached to the outside of a bottom-sealed, 2-inch diameter, 25-foot long, schedule 40 carbon steel pipe, inserted into a bore hole and grouted in place, as shown in Figure 8.4. The thermocouples will be sealed in stainless steel sheaths, attached to 24 gauge, Teflon-coated wire, extending to above ground. The coded wires will extend 5 feet beyond ground level, finished with compatible plugs for quick attachment to a thermocouple output display unit and housed in a weather-proof enclosure.

Large increases in soil temperature caused by the injection of steam create substantial changes in soil resistivity. Electrical resistance tomography (ERT) will be used to map the subsurface progress of steam injection as a function of space and time. ERT measurements will be made using a combination of surface and downhole measurements to map the steam propagation. The planned electrode well locations are shown on Figure 8.5. A schematic of the electrode strand is given in Figure 8.6. Resistivity measurements will be made before, during, and after steam injection, and will be processed to generate two-dimensional vertically oriented resistivity tomographs.

Two surface containment designs will also be installed and tested during the pilot-scale treatability study. The design of the actively cooled surface containment system (Figure 8.7) will allow condensable vapors to flow to an upper metal barrier where heat losses to the environment will allow condensation. Enhanced condensation will be achieved by active cooling of the exposed surface of the

barrier by installing a water sprinkler system. The passive barrier is simply a vapor barrier with soil placed on top for thermal insulation and protection. Beneath the vapor barrier, a gravel layer 3" thick would allow removal of vapors flowing up from the steamed soils through the application of a vacuum to the region. While the passive design may have an advantage in ease of installation, the active design would provide superior performance and greater control. The design which is most effective overall will be installed at the pilot-scale.

The three-well treatability test will require installation of most of the above ground equipment necessary for the pilot-scale implementation. The flow schematic of the above-ground processing equipment is shown in Figure 8.8. The effluent treatment system is designed to treat both the effluent vapor mixture and liquid water pumped from the extraction wells. The effluent vapor mixture enters a liquid trap where entrained liquid is trapped and pumped to an oil-water separator. The gas stream goes to an air-cooled heat exchanger where steam and the hydrocarbon vapor are condensed. The gas-liquid mixture then enters a vapor-liquid separator. Upon exiting the separator, the liquid phase is pumped to the oil/water separator, and the noncondensable air is removed with a vacuum blower to be treated by a thermal oxidizer before its release to the atmosphere.

Similarly, the effluent liquid treatment system recovers and treats liquids from the injection/extraction wells and surface separation vessels. Liquid mixtures are first separated and then metered upon exit from the oil/liquid separators. While oil is pumped to an oil storage tank, water is pumped through carbon canisters to reduce oil concentration to below discharge limits. In addition, the pH of the water is metered and treated, if necessary, before release to the sewer system. All hydrocarbon vapors that escape from the separators or the oil tank must pass through carbon canisters before their release to the atmosphere. Depending on availability and cost, all equipment components will be selected for the treatability test well operation. However, if the well pattern is expanded to pilot-scale dimension, then savings might be found in time and money if the equipment is sized for pilot-scale operation.

## 9. IMPLEMENTATION PLAN

The implementation plan consists of a list of tasks for implementation of the pilot-scale treatability study at Site 13, an implementation time line, and a site sampling and analysis plan. The following sections detail the work to be performed and the procedures to be followed in the operation and evaluation of the pilot scale treatability study. All work will be performed in accordance with the Contractor Quality Control Plan (Appendix B), Site Health and Safety Plan (Appendix C), and the Environmental Protection Plan (Appendix D).

## 9.1 TASKS

This section describes the tasks that will be performed during the pilot scale treatability study at Site 13.

### 9.1.1 Three-Well Treatability Study

The initial stage of the pilot scale treatability study will be implementation of the three well treatability study; this section describes the tasks that will be performed as part of this stage.

1. Perform additional site characterization for treatability test well siting. While the existing site characterization provides good delineation of the maximum extent of the subsurface waste oil, additional characterization of the subsurface concentration distribution is needed before the pilot-test wells are installed. Cone penetrometry with laser-induced fluorescence for soil oil concentration quantification will be used to determine the vertical waste oil distribution at 20 or more additional locations shown on Figure 9.1.
2. Survey the site to determine ground elevations and reference existing wells and prior soil borings. The surface topography of the site is to be quantified by standard surveying techniques. Surface elevations will be measured on a 20-foot grid. Once the existing topography is known and well locations are determined, the surface containment design and surface grading needs can be specified. To minimize the volume of surface soil to be moved, the drainage pattern for the surface containment system will be designed to best fit the surface topography.
3. Grade site to provide appropriate drainage from surface containment system. As shown in Figure 8.7, the grading will provide a sloped surface of one-quarter inch rise per foot of run for proper drainage of the surface containment system. The north and south sides of the graded region are to be sloped at a similar angle. For the three-well treatability test, grading will be performed only for the three wells shown in Figure 9.2.
4. Procure and have delivered to the site vacuum pump, downhole pumps, vapor condenser, oil/water separators, air and water treatment carbon canisters, and storage tanks. The operation of the treatability wells will require an oil-water separator, vacuum pump, two liquid storage tanks, carbon canisters and a thermal oxidation unit for treatment of extracted air, and an air-cooled heat exchanger for the vapors from the extraction wells. A second small oil-water separator will be installed on the liquid line exiting the liquid-vapor separator (see Figure 8.8). These equipment items will be procured and delivered to the site.

5. Install three injection/extraction wells. Continuous soil samples will be recovered during the installation of the injection/extraction wells. Three injection/extraction wells will be fabricated (as shown in Figure 8.8) and installed. Pilot borings will be drilled using a hollow stem auger with soil samples recovered continuously using a split-spoon sampler. The borings will then be reamed to 15 inches using reverse circulation drilling techniques. The wells will then be installed with number 2/12 sand packing except for grout plugs at the surface and above the depth of the metal plate separating the injection region of the well from the upper extraction region.
6. Analyze three soil samples from each boring for TRPH, BTEX, semi-volatile organic compounds (SVOCs), pesticides, and metals.
7. Develop injection/extraction wells to improve hydraulic communication with the water-bearing materials.
8. Analyze a groundwater sample from each injection/extraction for water-bearing materials for TRPH, BTEX, SVOCs, pesticides, and metals.
9. Conduct pumping tests to determine the transmissivity of the water-bearing materials.
10. Install 13 temperature observation wells. The temperature observation wells are to be installed by percussion insertion techniques at the locations shown in Figure 8.2. The temperature wells will be constructed from 2-inch diameter pipe to allow temperature readings at six thermocouple locations, and continuous temperature logging from inside the well.
11. For ERT purposes, seven electrode wells containing one electrode strand each will be installed using a cone penetrometer and surface electrodes will be emplaced in the ground surface as shown in Figure 8.5. One to two resistivity measurement sets will be made prior to steam injection; approximately one measurement per week will be made during injection; and about two will be collected after injection.
12. Survey all well locations and elevations.
13. Install surface containment system. For the treatability test, grading will be performed only for the three wells as shown in Figure 9.2, with the surfaces covered with two types of surface containment. The eastern slope, which will be covered with gravel, will have plastic sheeting laid over the gravel layer and sealed with temperature and hydrocarbon resistant glue or caulk to form an air tight plastic layer capable of withstanding one hundred degrees Celsius. The plastic sheet will then be covered with a six-inch thick layer of

clean soil to provide insulation. The western slope will be covered with a sandwich of flat steel sheeting on top and corrugated steel sheeting on bottom riveted together with one-half inch spacers in between as shown in Figure 9.2. The steel sheeting will be supplied to the site as panels to be assembled and connected with caulk and rivets to form an air-tight cover. Because the injection/extraction wells will be in place when the surface containment system is laid, both the plastic and steel coverings must be cut to form around the wells and sealed at these openings.

14. Hook up vacuum lines, compressed air lines, and steam lines to wells. The steam inlets to the wells will be connected to the steam line at the manifold using steel pipe and rubber hose as appropriate. Orifice plate flow meters will be installed two feet from the well head and fitted with electronic differential pressure transducers for flow rate calculation. The extraction ports from the wells will be connected to the vapor extraction and liquid treatment systems using hose or pipe as appropriate. Compressed air will be connected to the downhole pump gas inlet port using high pressure hose or piping.
15. Operate treatability test system and collect operational samples for a period of 30 days. Steam will be injected into one well while fluids are pumped from the other two wells for a period sufficient to bring the oil-laden soil to steam temperatures. The radius of influence of the steam from the well is to be determined by monitoring subsurface temperatures. Then, the steam will be cycled between wells in a manner that optimizes vapor recovery and oil pumping rates. Operation will be under daily direction from the Project Manager or designee.
16. Prepare a report summarizing the results of the three-well treatability test and making recommendations for implementation of the 15-well pilot-scale test, including any revisions to the planned design.

### **9.1.2 Pilot-Scale Test**

Assuming that the results of the three-well treatability test indicate that continuation of the pilot scale study is viable, the 15-well pilot-scale test will be implemented. This section describes the tasks that will be performed as part of that test.

1. Produce the 100% design for the expansion to the pilot-scale test. The plans will be used for construction of the surface containment system, temperature monitoring wells, injection/extraction wells, electrode wells, equipment pad, piping, and electrical systems by subcontractors. Equipment specifications will be produced by sizing-up the three-well test data and evaluation of field operation computer simulations, calibrated to the three-well performance.



2. Procure any additional or replacement equipment (i.e., downhole pumps, vapor condenser, oil/water separators, air and water treatment carbon canisters, and storage tanks) as needed to meet pilot-scale projected rates and conditions.
3. Survey the site as described for the three-well treatability study.
4. Grade site to provide appropriate drainage and install surface containment system. The graded surfaces will be covered with the best of the two surface containment systems tested during three-well operation, with potential design improvements based on three-well field experience.
5. Install additional injection/extraction wells, develop and sample these wells as described for the three-well treatability test.
6. Install additional temperature-monitoring wells for pilot-scale test as described for the three-well treatability test.
7. Install additional electrode wells as described for the three-well treatability test.
8. Install appropriate surface containment system.
9. Hook up vacuum lines, compressed air lines, and steam lines to wells. The steam inlets to the wells will be connected to the steam line at the manifold using steel pipe and rubber hose as appropriate. Orifice plate flow meters will be installed two feet from the well head and fitted with electronic differential pressure transducers for flow rate calculation. The extraction ports from the wells will be connected to the vapor extraction and liquid treatment systems using hose or pipe as appropriate. Compressed air will be connected to the downhole pump gas inlet port using high pressure hose or piping.
10. Operate pilot-scale test system and collect operational samples for a period of 180 days or until recovery rates drop to sustained values less than 25 gallons of oil per day. The process will be operated continuously for the 180-day period, with steam injection alternating between various well. After the contaminated zone within the pilot pattern reaches steam temperature, the steam will be cycled between wells in a manner that optimizes vapor recovery and oil pumping rates. Operation will be under daily direction of the Project Manager or designee.
11. Conduct post-demonstration sampling to measure reduction in contaminant levels.

12. Produce a final report on the performance of the pilot-scale treatability test. The report will contain sufficient data and analysis to support evaluation of the use of SEE for full-scale cleanup including a summary of field conditions, all analytical data obtained, and information illustrating optimum operating conditions.
13. Produce 75% designs for the full-scale surface containment system, temperature monitoring wells, injection/extraction wells, process equipment, piping, and electrical systems. Equipment specifications will be produced by sizing up pilot-scale test data and evaluating additional field operation computer simulations calibrated to past field performance.

## 9.2 TIME LINE

The time tables and critical paths for the tasks outlined in Section 9.1 are provided as Figures 9.3 through 9.5.

## 9.3 SITE SAMPLING AND ANALYSIS PLAN

Sampling and analysis will be performed during the implementation and operation of the pilot-scale study for the SEE process at Site 13 to achieve the following objectives:

- Provide further characterization of the extent of chemicals and refinery wastes identified in the soil at Site 13;
- Characterize the hydraulic properties of the subsurface waste-bearing zone;
- Assess the performance of the prototype injection/extraction well design;
- Monitor the performance of the SEE system and the above-ground treatment equipment to identify potential difficulties in above-ground fluid treatment;
- Provide an overall assessment of the technical feasibility of the SEE process to restore Site 13; and
- Characterize wastes for disposal purposes.

This sampling and analysis plan describes the field activities, sampling, and analyses that will be performed to achieve the above objectives. Specific tasks that will be performed are described in Section 9.1. The data obtained during the pilot-scale study will be used to assess the effectiveness of the SEE process in

reducing chemical concentrations in the waste bearing zone. Many field and sampling procedures identified in this SAP are described in "Standard Operating Procedures" dated June 1995, prepared by the BERC. These SOPs are in draft form and are referenced in the SAP as appropriate. Draft versions of the SOPs referenced are included in Appendix F, Supplemental Information. These SOPs will be finalized and submitted under separate cover.

### **9.3.1 Additional Site Characterization**

As discussed in Section 9.3, it will be necessary to conduct additional sampling to characterize the extent of refinery wastes in the subsurface prior to locating the three injection/extraction wells for the three-well treatability test. To achieve this, cone penetrometer testing (CPT) and laser induced fluorescence for identifying oil concentrations in soil will be used at a minimum of the 20 locations shown on Figure 4.2 CPT and laser induced fluorescence methods are described below.

#### **9.3.1.1 Cone Penetrometer Testing**

CPT methods are described in SOP No. 10.2; soundings obtained at each CPT location will include the friction ratio, friction resistance, and differential pore pressure ratio to obtain information regarding subsurface lithology as well as pore pressure to measure water pressure in the formation. At each location, CPT soundings will be obtained to a maximum depth of 20 feet below ground surface. Groundwater samples will not be collected. Upon completion of each sounding and measurement of laser induced fluorescence, each CPT location will be backfilled with a neat cement grout containing no more than five percent bentonite.

#### **9.3.1.2 Laser-Induced Fluorescence**

Laser-induced fluorescence will be used to identify PAHs present in petroleum hydrocarbons by their fluorescent response to excitation by ultra-violet light. *In situ* measurements of the PAH levels will be obtained using an *in situ* fluorometer equipped with two optical fibers, a timing circuit fiber, and the downhole irradiation fiber. The PAH levels can be used to infer petroleum hydrocarbon levels. This measurement method will provide a continuous vertical profile of relative petroleum hydrocarbon concentrations identified through the total depth of the CPT sounding.

### **9.3.2 Injection/Extraction Well Installation**

The locations of the injection/extraction wells to be installed for the three well treatability test will be selected on the basis of additional site characterization

performed as described in Section 9.3.1, above. The wells will be located in the areas where the highest petroleum hydrocarbon levels are identified. Expected locations are shown on Figure 4.1. The location of the additional twelve wells to be installed for implementation of the 15 well pilot-scale test will be selected on the basis of the results of the treatability test. Methods planned for the installation and sampling of injection/extraction wells during both stages of the pilot-scale treatability study are described below.

#### 9.3.2.1 Installation of Soil Borings

A truck mounted drilling rig equipped with eight-inch outside diameter hollow-stem augers will be used to drill initial soil borings to a total depth of 25 feet bgs for soil sample collection. Upon completion of soil sampling, the augers will be removed from the boring and it will be reamed to a 15-inch diameter using reverse circulation drilling techniques. During reaming, water will be added to the boring to maintain hydrostatic pressure in the boring and control potentially heaving sands. Drill cuttings will be contained in 55-gallon drums or a covered roll-off bin and appropriately labeled for subsequent disposal.

#### 9.3.2.2 Soil Sampling

Soil samples will be collected continuously from ground surface to total depth using a two-inch diameter split spoon sampler lined with six-inch long precleaned stainless steel or brass tubes. This soil sampling procedure is described in SOP 3.2. All recovered soils will be logged in the field and recorded on the boring logs by the project geologist under the supervision of a registered geologist using the Unified Soil Classification System (USCS).

Upon retrieval, each sample will be prepared for potential analysis. Each end of the sample liner will be covered with aluminum foil or Teflon sheeting and the liner will then be capped with a polyethylene lid, taped, labeled, and handled as described in Section 9.3.11.

#### 9.3.2.3 Injection/Extraction Well Construction

The injection/extraction wells will be constructed as indicated on Figure 8.3. Well construction methods are described in SOP 8.1 and in more detail below. The casing will consist of eight-inch diameter blank carbon steel with two screened intervals constructed of 304 stainless steel with 0.02 inch openings installed at four to 14 feet and 19 to 24 feet bgs. The screen will be continuous slot with V-type slot openings. The bottom of the casing will be completed with welded or threaded bottom plug. The screened intervals will allow dewatering from the upper screened interval and injection of steam from the lower portion.

A steel plate will separate the injection interval from the overlying pumping interval.

The casing and screen will be installed directly into the boring. To complete the wells, clean imported number 2/12 clean silica sand will be poured into the boring and will extend to the top of the deepest screened interval. A five foot thick seal of hydrated 3/8 inch bentonite pellets will then be placed opposite of the blank casing. Above this, clean imported number 2/12 silica sand will be emplaced to the top of the uppermost screened interval. These well completion materials will be emplaced through a tremie pipe.

After the uppermost filter pack has been installed, a sanitary seal consisting of 3/8 inch diameter bentonite pellets will be emplaced and hydrated. The remainder of the annular space will be filled with a neat cement grout containing no more than five percent bentonite. A six inch concrete pad will be constructed around the well head. A water tight locking cap will temporarily be placed on the well head until pumping and injection equipment is installed and the well is hooked up to the treatment system.

#### 9.3.2.4 Well Development Methods

At least 48 hours after completion, the wells will be developed by the drilling contractor using a surge block and bailer. Well development procedures are described in SOP 8.2. A field geologist will observe the field activities and monitor water quality parameters during development. The water quality parameters to be monitored include temperature, pH, and specific conductance. Purging will continue until all three parameters have stabilized and the purge water is relatively free of sediment or there is no observable change in the amount of sediment in the purge water. A minimum of three well volumes of liquid will be removed and purge water will be contained on-site in DOT-approved 55-gallon drums and appropriately labeled.

#### 9.3.2.5 Water Level and Product Thickness Measurements

Prior to groundwater sample collection, the static water level and product thickness in each monitoring well will be checked at least 24 hours following development. These procedures are described in SOPs 5.1 and 5.2, respectively. Samples will be inspected in the field for presence of odor or sheen in addition to the above evaluation. Both water level and product thickness measurements are measured to the nearest 0.01 foot.

### 9.3.2.6 Groundwater Sampling Methods

Groundwater sampling methods are described in SOP 9.1. Prior to sampling, the well will be purged using a pump to remove a minimum of three and a maximum of 10 well volumes of liquid. The pH, specific conductance, and temperature of the purge water will be closely monitored, and purging will continue until all three parameters have stabilized. If a well does not recharge fast enough to permit purging three well volumes, the well shall be pumped or bailed dry and sampled as soon as the water level has recovered to 80 percent of the original level. The purged water will be stored on-site in 55-gallon DOT-approved drums and appropriately labeled.

Groundwater samples will be obtained in a disposable polyethylene bailer. Water samples will be poured directly from the bailer into the sampling bottles specified in Table 9.1 for each analytical method. Samples for analysis of volatile organic compounds will be collected in 40 milliliter glass vials with Teflon lined lids. No head space will be present in the sample container when it is capped. All groundwater samples will be labeled and handled as described in Section 9.3.11 .

### 9.3.2.7 Laboratory Analyses

Three soil samples from the depths of two, seven, and 12 feet bgs in each boring and one ground water sample from each well will be analyzed at a Navy certified laboratory for TRPH, BTEX, SVOCs, pesticides, and metals by the analytical methods specified in Table 9.2. The numbers of samples to be analyzed is summarized in Table 9.3. The remaining soil samples will be taken by BERC engineers for additional tests at UCB labs. The sampling intervals selected for analysis include a sample from the vadose zone and the interval where the highest chemical concentrations were identified during the SCAPS project at Site 13 (PRC, 1994a ).

### 9.3.3 Hydraulic Testing

To identify the transmissivity of the water bearing materials, a single well pumping test will be conducted in each injection/extraction well installed during the three-well treatability study. The tests will be performed by pumping the well at a constant rate and obtaining appropriate water level measurements during pumping of the well as well as during recovery to measure drawdown and recovery of the water levels. Drawdown data will be analyzed using the Jacob time-drawdown method to calculate the transmissivity of the water-bearing materials.

### 9.3.4 Temperature Monitoring Well Installation

To monitor temperatures at the injection point, temperature monitoring wells will be installed adjacent to each of the injection/extraction wells installed during the pilot-scale treatability study. To monitor temperature changes within the remainder of the treatment area, 13 temperature monitoring wells will be installed for the three-well treatability test and 30 temperature monitoring wells will be installed for the 15-well pilot-scale test. Estimated locations for these wells are shown on Figures 8.1 and 8.2.

The planned well construction is shown on Figure 8.6. The wells will be installed by pushing 2-inch outside diameter carbon steel schedule 40 pipe directly into the soil to a total depth of approximately 25 feet below ground surface using van-mounted percussion insertion techniques. The casing will be completed with a two-inch NPTF cap at the bottom and the well head will be completed with a weatherproof T-Type thermocouple terminal box. T-Type shielded stainless steel thermocouple wire with beads spaced every four feet will be installed inside the casing for temperature monitoring.

### 9.3.5 Electrical Resistance Tomography

Seven electrode wells will be installed each containing one strand with five regularly spaced electrodes. Between each well pair, ten surface electrodes will be emplaced for a total of 60 surface electrodes.

#### 9.3.5.1 Surface Resistivity Survey

Surface resistivity measurements will be obtained before the electrode wells are installed. For this survey, four metal stakes will be driven approximately six inches into the ground in a linear array. Each stake will be electrically connected to a data acquisition system that transmits a current of about 0.5 amps through the transmitting electrodes and measures a voltage potential through the receiving electrodes. The apparent resistivity is then calculated from an equation based on the voltage received. This information will be used to determine the size of the electrodes needed for the electrode wells.

#### 9.3.5.2 Electrode Well Installation

Electrode wells will be installed using a cone penetrometer. The cone and a hollow push rod will be pushed into the ground and a strand of five regularly spaced electrodes will be lowered into the push rod. The push rod will then be pulled from the ground leaving the cone and the electrode strand in the ground. A schematic of the electrode well is shown on Figure 8.6. Following electrode

installation ten surface electrodes will be permanently emplaced between well pairs along the lines indicated on Figure 8.5. Data from the surface electrodes and the electrode wells will be used to create two dimensional vertically oriented resistivity tomographs. A minimum of one set of resistivity measurements will be made before steam injection to collect base line data, set up the measuring system, quantify measuring noise, and trouble shoot the system.

### **9.3.6 Operational Monitoring**

During operation of the three-well treatability test and the pilot-scale test, a BERC engineer or technician will monitor the performance of the system. The engineer or technician will ensure that the system is operating within established parameters or make adjustments to attain compliance with operating parameters.

The specific data requirements needed to determine the progress of the advancement of the steam front and the progress of the cleanup include both temperature, electrical resistance, flow rates, and concentration data. The temperature data will be used to determine the rate at which the steam is flowing through the contaminated region. Electrical resistance data will be used to map the subsurface progress of steam injection. The steam flow rates and the concentrations of hydrocarbon compounds in the effluent steams will be used to determine the progress of the steam stripping of the volatile and semi-volatile compounds from the subsurface. In addition, the effluent of the water treatment system will be sampled to determine that the effluent water quality meets the necessary requirements for discharge. A summary of operational samples that will be collected is presented in Table 9.4 .

#### **9.3.6.1 Influent and Effluent Sampling**

During operation of both phases of the pilot-scale treatability study, effluent from the wells will be pumped directly to the water treatment system installed for the pilot-scale treatability study. Influent water sampling will provide an measurement of the amount of hydrocarbons being removed by the system. Effluent water sampling will provide a demonstration that the discharge requirements of the base water treatment plant are being met. Discharge limitations for the water treatment plant are included in Table 9.5.

At the startup of operations during each phase of the pilot scale study, the influent and effluent of the system will be sampled daily for one week and the samples will be analyzed for TRPH, BTEX, SVOCs, and pesticides by the analytical methods identified in Table 9.2. To demonstrate compliance with requirements for discharge to the base water treatment plant, effluent samples will also be analyzed for arsenic, cadmium, chromium, copper, cyanide, iron, lead, mercury,



nickel, oil and grease, pH, phenolic compounds, silver, total identifiable chlorinated hydrocarbons, zinc, and total toxic organics by the methods identified in Table 9.2. Depending on the results of the sampling, the sampling frequency and number of analyses may be reduced after one week after consultation with the Resident Officer in Charge of Construction (ROICC) and the operator of the base water treatment plant.

#### 9.3.6.2 Temperature Measurements

An infrared thermocouple will be utilized to obtain a continuous temperature profile at each temperature observation well twice daily. The infrared probe will be lowered at a constant rate into the temperature observation well and the temperatures will be sent to a Macintosh-based computerized data collection system. Plots of temperature versus depth will be generated every one to three days to monitor the location of the steam and heated zones around the injection/extraction wells.

#### 9.3.6.3 Electrical Resistivity Measurements

Weekly resistivity measurements will be made using the electrode wells and surface electrodes during operation of the SEE system to generate a two-dimensional, vertically oriented resistivity tomograph for mapping progress of the steam.

#### 9.3.6.4 Flow Rate Measurements

The flow rate measurements are needed in order to determine the steam injection rates and the rate at which the petroleum hydrocarbons are being removed from the subsurface. Steam flow rate will be measured using orifice plates and differential pressure measurements. The steam flow rate will be logged twice daily, or automatically in electronic form using a Macintosh-based computerized data acquisition system.

Total pumped liquid flow rates will be obtained by stroke counters on downhole pumps, and individually measured stroke volumes. Stroke volumes will be measured on a weekly basis throughout SEE operations. Liquid volumes exiting the oil/water separators will also be measured using totalizing meters and logged twice daily to calculated pumping rates.

Accurate measurements of the amount of energy injected into the subsurface as steam will be needed to accurately estimate the energy that is used to heat up the subsurface. The measurement of the temperature and the total volume flow rate of both liquid and vapor phases is also required to determine the amount of

energy removed from the system as well as to estimate the total volume of hydrocarbons removed.

#### 9.3.6.5 Pressure Monitoring

The pressure of air in the air injection line will be measured to control the pressure of the compressed air injected to drive the submersible pumps installed in the injection/extraction wells.

The steam pressure of the steam injection line will be measured to control the steam injection pressure at the well head.

The vapor pressure of the vapor mixture in the vapor extraction line will be measured to monitor the vacuum pressure in the extraction lines. Pressure before and after the vacuum blower are measured to monitor the operations condition of the vacuum blower.

### 9.3.7 Post-Demonstration Sampling

At the completion of the pilot-scale test, resistivity measurements will be made using the electrode wells and surface electrodes to generate a two-dimensional, vertically oriented resistivity tomograph. Soil samples will also be collected and laboratory analyzed to identify the level of chemicals left in the soil. A total of five soil borings will be drilled for collection of soil samples. The locations of the borings will be determined after information on the shape of the steam zone can be inferred from the temperature profiles and the resistivity tomographs. The borings will be located in the areas where the highest petroleum hydrocarbon levels were previously identified.

#### 9.3.7.1 Installation of Soil Borings

A portable, hydraulically driven soil coring system will be used to collect continuous soil samples to a total depth of 25 feet below ground surface for soil sample collection. This method utilizes two nested sampling rods that are driven simultaneously. The small-diameter inner rod is used to obtain and retrieve sample cores. The larger rod serves as a temporary drive casing to prevent caving into the boring. Upon completion of soil sample collection, each boring will be backfilled with a neat cement grout containing no more than five percent bentonite. No soil cuttings will be produced using this drilling method.

### 9.3.7.2 Soil Sampling

Soil samples will be collected continuously from ground surface to total depth in 1-1/2 inch diameter by six-inch long precleaned stainless steel or brass tubes using a sample barrel attached to the inner rod which is advanced during drilling. All recovered soils will be logged in the field by the project geologist, under the supervision of a registered geologist, using the Unified Soil Classification System (USCS).

Upon retrieval, each sample will be prepared for potential analysis. Each end of the sample liner will be covered with aluminum foil or Teflon sheeting and the liner will then be capped with a polyethylene lid, taped, labeled, immediately placed in a cooler and handled as described in Section 9.3.11 .

### 9.3.7.3 Laboratory Analyses

Seven soil samples from the depths of two, four, six, eight, 10, 12, and 14 feet in each boring will be analyzed at a Navy-certified laboratory for TRPH, BTEX, SVOCs, and pesticides by the analytical methods specified in Table 9.2. The remaining soil samples will be taken by BERC engineers for additional tests at UCB labs. A larger number of samples are being taken for post-demonstration sampling to demonstrate whether chemicals from the steamed zone have migrated upwards.

## 9.3.8 Decontamination Procedures

All sampling and downhole drilling equipment will be decontaminated prior to and between uses to minimize the potential for the introduction of off-site contaminants as well as cross contamination of samples. All sampling equipment will be decontaminated by washing with a solution of tap water and non-phosphate detergent such as Lacunas or equivalent. Next, the equipment will be rinsed in succession with tap water, isopropanol, and deionized water. All downhole drilling equipment will be steam-cleaned. Decontamination of drilling and downhole equipment is described in SOP 6.2. Wastewater generated during decontamination will be contained in DOT-approved 55-gallon drums and appropriately labeled.

## 9.3.9 Quality Assurance/Quality Control Procedures

Flow rate, temperature, mass of waste removed, and pressure readings will be taken in a manner that is representative of UCB scientific standards. Discharge compliance measurements will be supported by independent analytical analysis. Our goal is to maintain  $\pm 10\%$  accuracy on all mass and energy balances, which

will require calibration diligence, backup of critical data acquisition systems, and extensive subsurface temperature measurements.

Quality assurance/quality control (QA/QC) procedures that will be followed for this project are addressed in the Contractor Quality Control Plan included in Appendix B. This section identifies the field QA/QC samples that will be analyzed.

Field QA/QC samples to be collected and analyzed are addressed in SOP 18.1. The following QA/QC samples will be collected during soil and groundwater sampling. Only trip blanks will be prepared during operational monitoring. The planned number of QA/QC samples for each sampling event and the planned analyses for each sample are summarized in Table 9.2.

- Trip blanks will be analyzed for BTEX. One trip blank will be prepared for each cooler of soil or groundwater samples to be analyzed for BTEX;
- Equipment rinseate samples will be analyzed for the same parameters as the soil or groundwater samples being analyzed. A minimum of one equipment rinseate sample per week will be prepared. Rinseate samples collected during soil sampling will be prepared by collecting the final rinseate from the soil sampling equipment. Rinseate samples collected during groundwater sample collection will be prepared by pouring ASTM Type II deionized water into the disposable bailers and then into the appropriate sample containers;
- Field blanks will be analyzed for the same parameters as the soil or groundwater samples being analyzed. One field blank will be prepared from each source of decontamination water used during each sampling event by pouring the water directly into the appropriate sampling containers;
- Field duplicates of groundwater samples will be analyzed for the same parameters as the groundwater samples. Field duplicates are collected at an approximate rate of ten percent of the groundwater samples. No duplicate soil samples will be collected.

### **9.3.10 Waste Disposal**

Waste materials to be disposed of during both phases of the pilot-scale treatability study include drill cuttings, decontamination fluids, purged well water, recovered free product, and spent carbon canisters from the water treatment system. Disposal of these items is discussed in this section.

#### 9.3.10.1 Soil

Drill cuttings generated during well installation will be containerized and left on-site at the end of each day in DOT-approved 55-gallon drums or roll-off bins. Selection of the appropriate disposal method for the cuttings will be based on the analytical results for soil samples from the borings.

#### 9.3.10.2 Wastewater

Wastewater will be generated during the decontamination of the drilling and sampling equipment; well development and groundwater sampling activities; and hydraulic testing. The wastewater will be collected and stored in DOT-approved 55-gallon drums, and treated with the water treatment system installed for the pilot-scale treatability study. After treatment by oil/water separation and activated carbon, the wastewater will be discharged to the base water treatment plant.

#### 9.3.10.3 Free Product

Free product will be accumulated in the oil/water separators or DOT-approved 55-gallon drums, depending on the recovery rate. Free product from the separators will be pumped directly into a vacuum truck by a licensed commercial service and transported to a licensed off-site facility for disposal or recycling. If the drums are used, they will be transported by a licensed hauler to a licensed off-site facility for disposal or recycling.

#### 9.3.10.4 Spent Carbon Canisters

Spent carbon canisters will be picked up by a licensed waste hauler and transported to a licensed facility for regeneration.

### 9.3.11 Sample Handling and Analysis

Sample handling procedures are described in SOP 2.1. Upon collection, each sample will be labeled according to the specifications contained in SOP 17.1 and numbered in accordance with SOP 17.2. After collection, each sample will be placed in a seam-sealing polyethylene bag and excess air will be removed. Samples will be placed in a cooler with crushed or cubed ice contained in a double-bagged self-sealing polyethylene bag. The samples will be picked up daily by the laboratory or delivered daily to the laboratory by field personnel using proper chain-of-custody procedures described in SOP 1.1. Documentation of final disposition of all samples collected will be provided to the Navy.

### **9.3.12 Surveying**

Prior to any grading, existing ground surface elevations will be surveyed on a 20-foot grid. Existing soil borings, existing groundwater monitoring wells, and all wells installed during the pilot-scale treatability study will be surveyed to the nearest 0.01 foot and the location will be surveyed to the nearest 0.10 foot. Surveying procedures are described in SOP 23.1.

## **10. PROJECT MANAGEMENT**

A program and project organization chart for the pilot-scale treatability study is presented on Figure 10.1. As indicated on the chart, UCB will be responsible for providing program management for the overall partnership agreement with the U.S. Navy. UCB has subcontracted to E2 Consulting Engineers, (E2) to provide project management services for the pilot scale treatability study at Site 13. The responsibilities of each of the positions identified on the organization chart are described in Section 2 of the CQCPP.

During implementation of the study, BERC will provide initial design documents which will be finalized by E2 or a subcontractor to E2. Many field activities will be conducted by BERC and subcontractors to E2 with oversight by E2 who has a California registered geologist on staff. E2 will procure equipment and subcontract to other firms for construction and maintenance of the pilot scale treatability system. BERC will collect operational samples during both phases of the study. E2 and BERC will jointly be responsible for report preparation.

## 11. REFERENCES

BERC, 1995 "U.C. Berkeley Treatment Technologies To Cleanup Installation Restoration (I.R.) Site No. 13 Former Oil Refinery", Contract N62474-94-D-7430, Delivery Order (DO) No. 0003, March 6 (2nd revision).

EPA, 1988 Guidance for Conducting Remedial Investigations and Feasibility Studies, EPA/540/G-89/004.

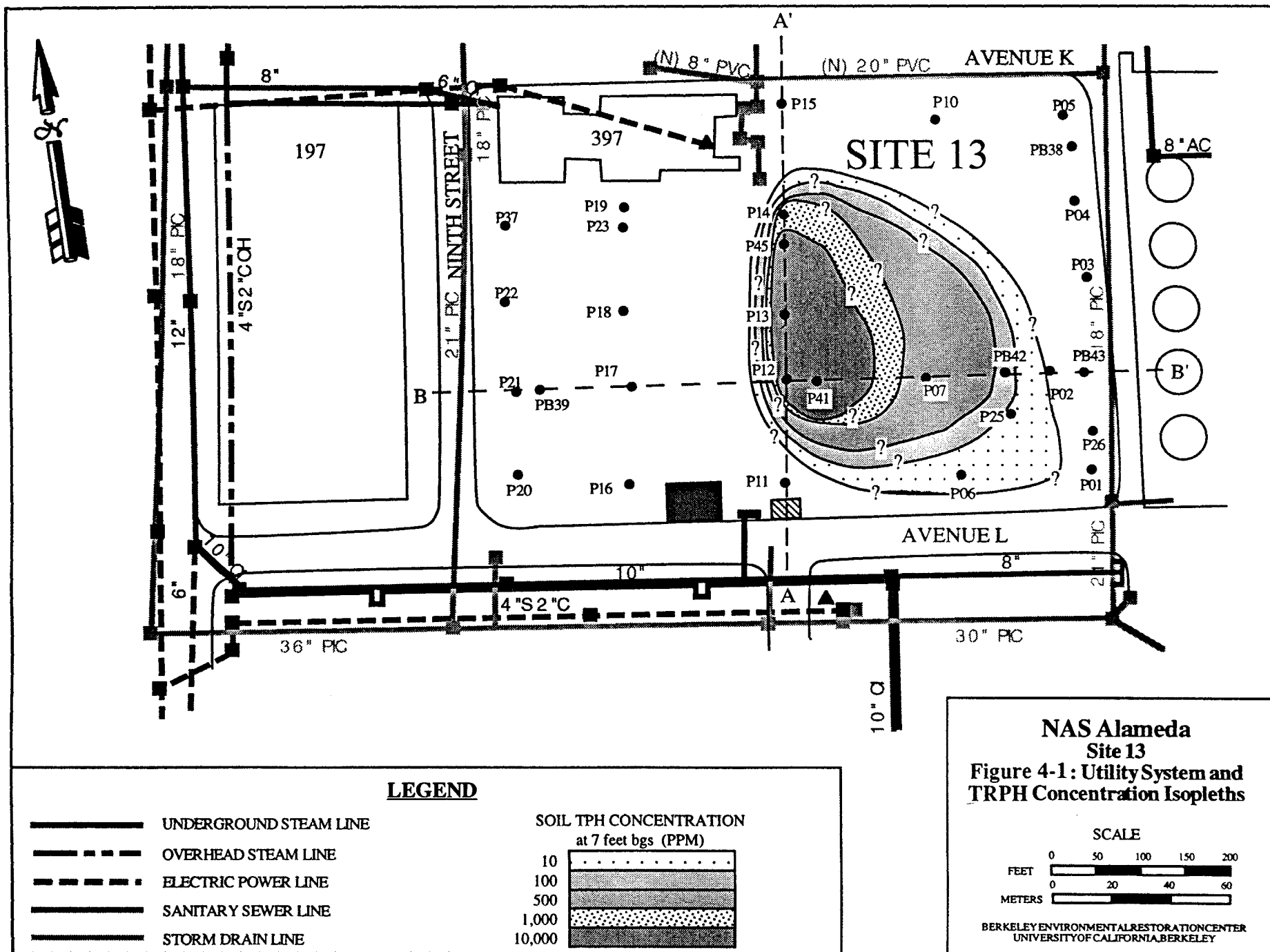
PRC, 1994a. SCAPS Push and Intercalibration/Validation Boring Summary Report for NAS Alameda-Site 13, Old Refinery Site, Alameda, CA, August 19.

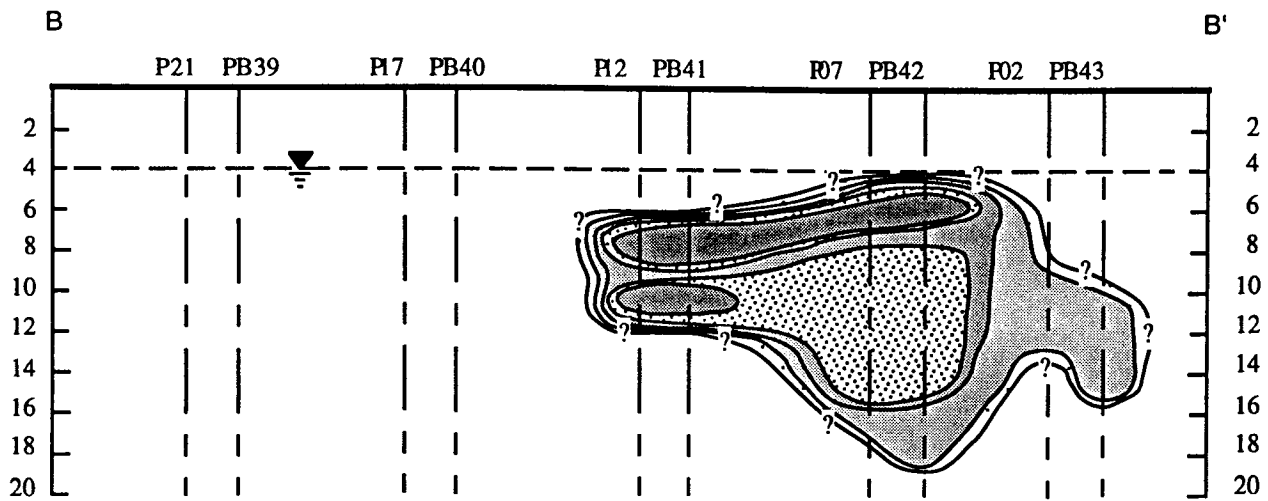
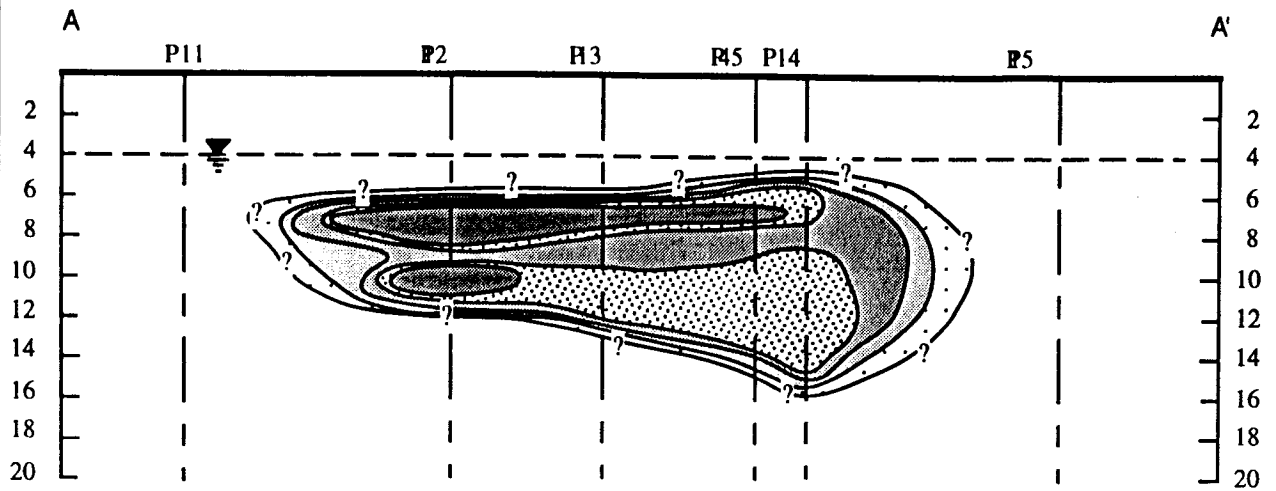
PRC, 1994b. Naval Air Station, Alameda, Alameda, California, Remedial Investigation/Feasibility Study Site Conceptual Models, Preliminary Draft. September 22.

PRC, 1994c. Memo from Susan Willoughby to Steve Collins, University of California, Berkeley. December 15.

## FIGURES

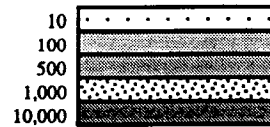




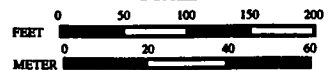


**NAS Alameda**  
**SITE 13**  
**Figure 4.2: TRPH on**  
**Cross-Sections A-A' and B-B'**

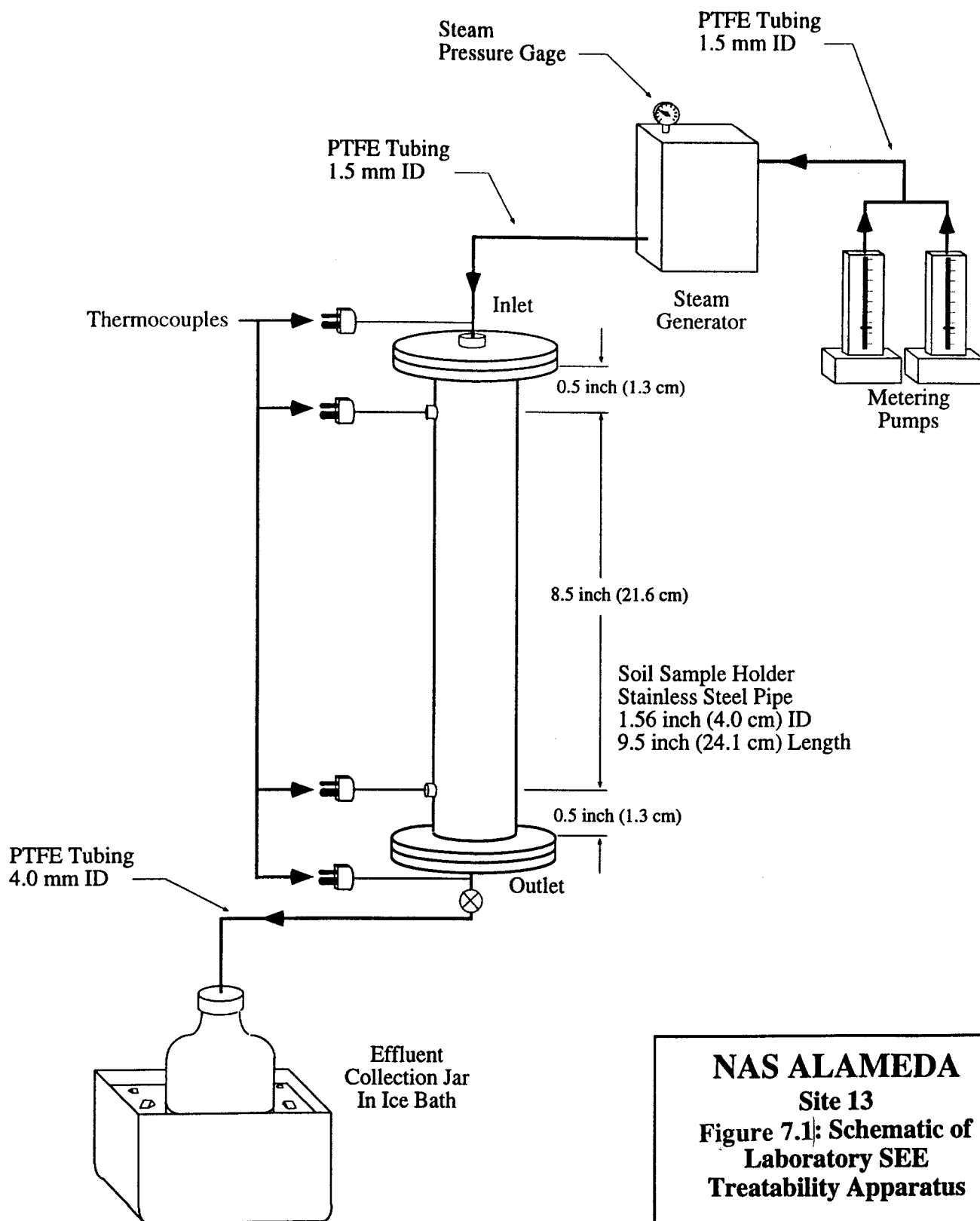
CONCENTRATION (PPM)



SCALE



BERKELEY ENVIRONMENTAL RESTORATION CENTER  
 UNIVERSITY OF CALIFORNIA, BERKELEY

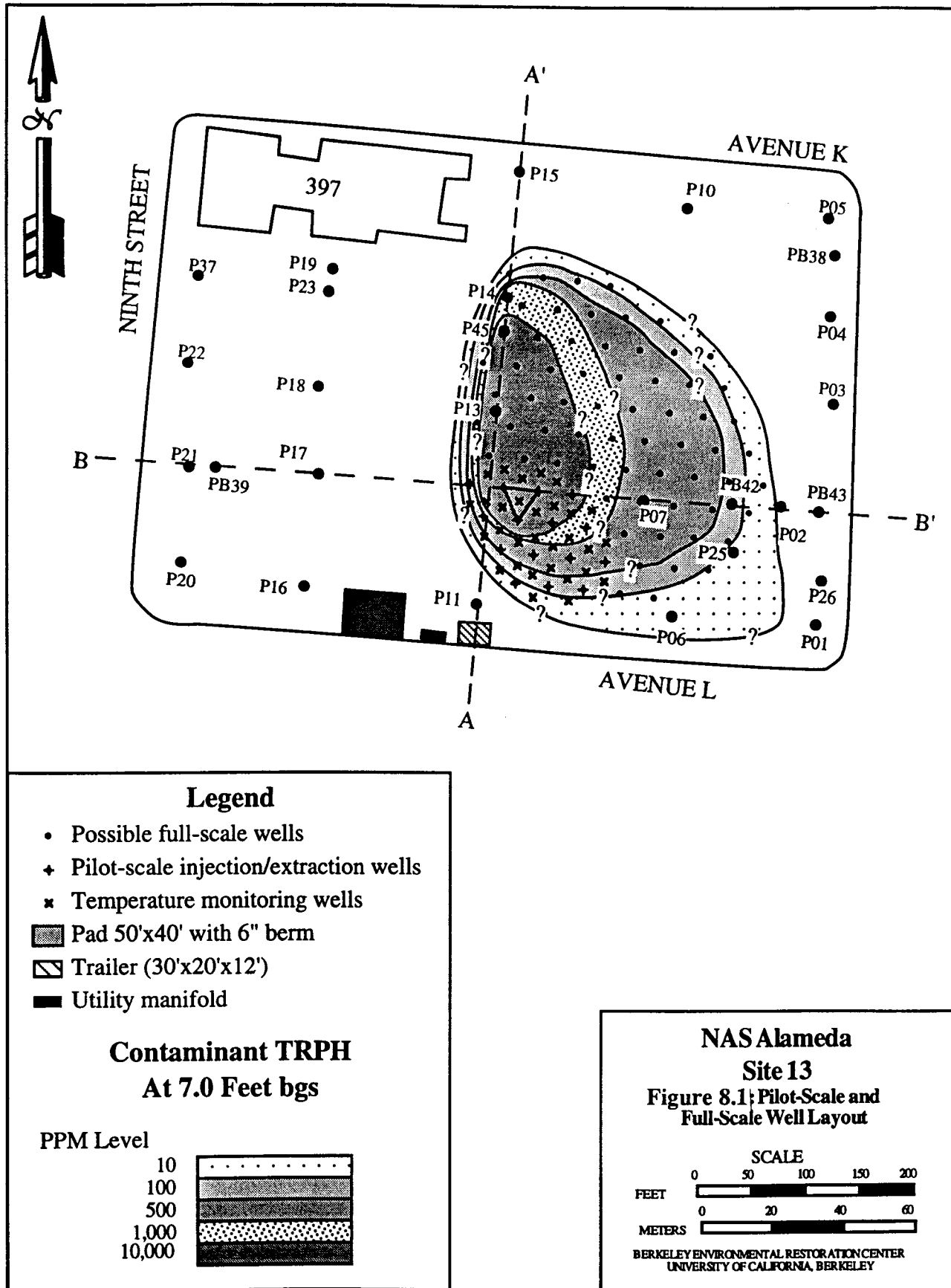


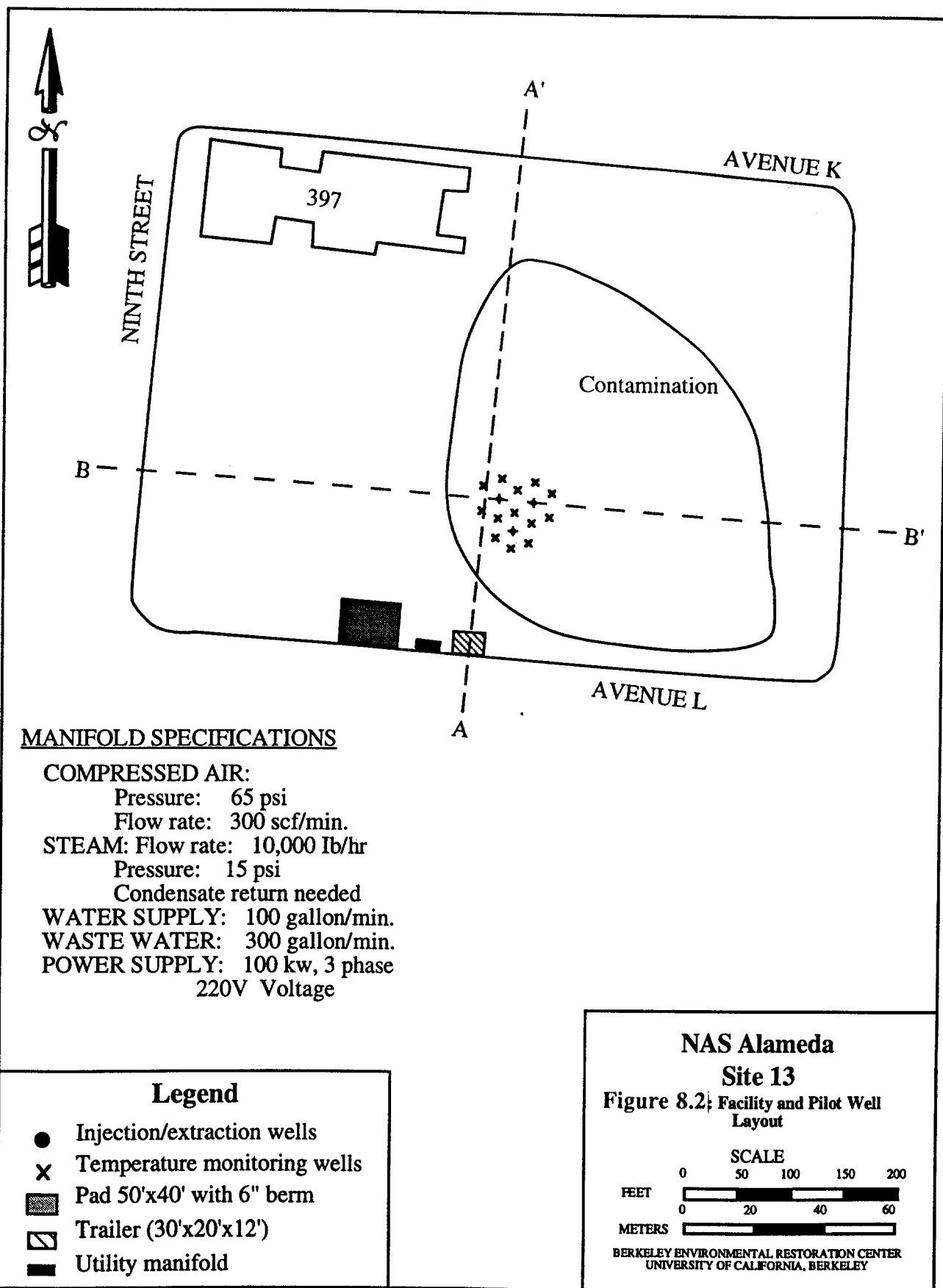
**NAS ALAMEDA**

**Site 13**

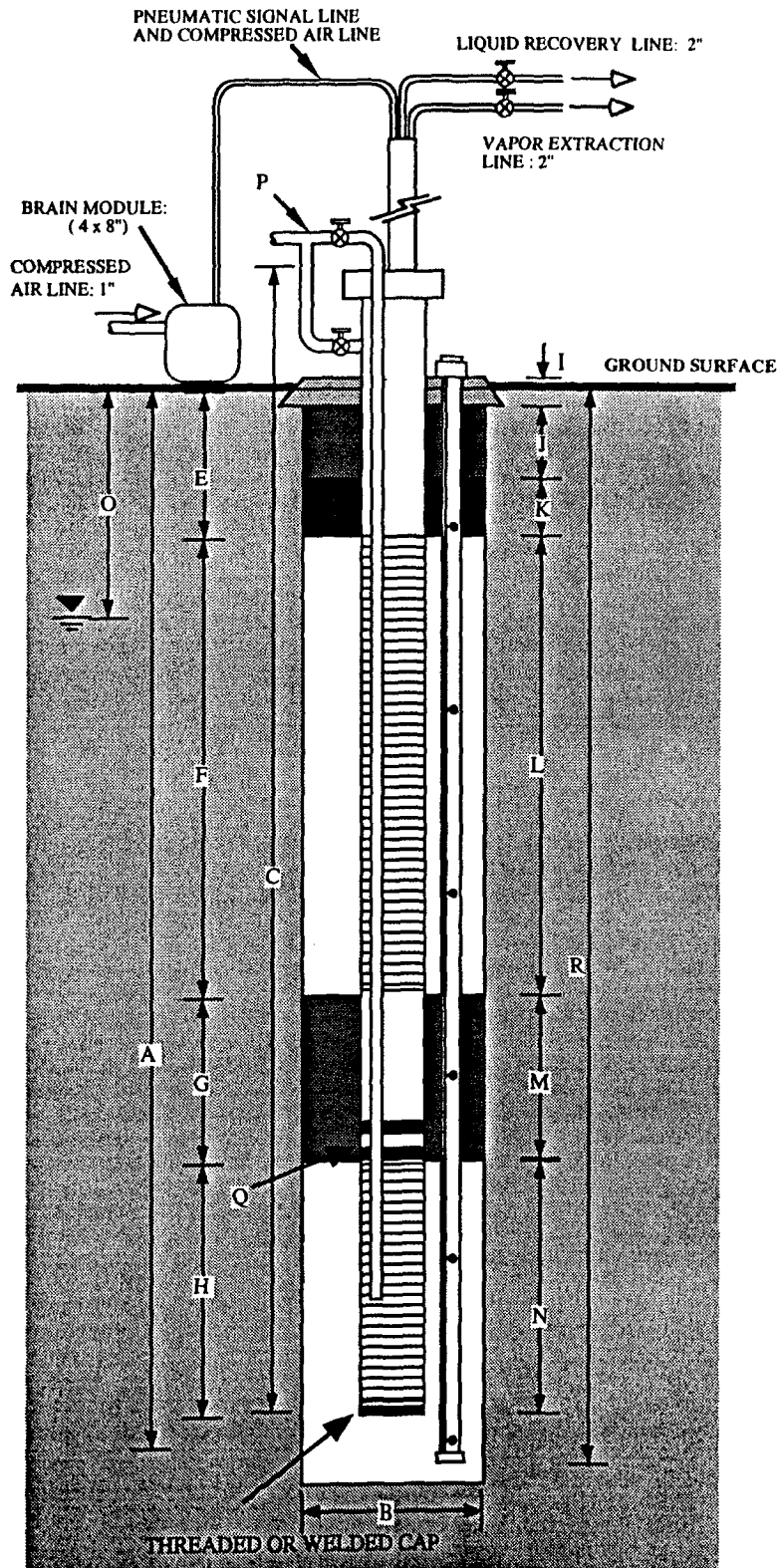
**Figure 7.1: Schematic of  
Laboratory SEE  
Treatability Apparatus**

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## INJECTION / EXTRACTION WELL



### EXPLORATORY BORING

- A. Total depth --- 24 ft
- B. Diameter --- 15 in  
Drilling method --- Hollow stem auger

### WELL CONSTRUCTION

- C. Total casing length --- 11 ft  
Material --- Carbon Steel
- D. Diameter --- 8 in
- E. Depth to top of screen --- 4 ft
- F. Screen length --- 10 ft  
Screen type --- continuous-slot screen  
Vtype slot opening  
Screen size --- 0.02 in  
Screen material --- 304 Stainless Steel  
Screen number --- No. 20
- G. Casing length --- 5 ft  
Material --- 304 Stainless Steel
- H. Screen Length --- 5 ft  
Screen type --- continuous-slot screen  
Vtype slot opening  
Screen size --- 0.02 in  
Screen material --- 304 Stainless Steel  
Screen number --- No. 20
- I. Surface seal --- 0.5 ft  
Material --- Concrete
- J. Backfill --- 2 ft  
Material --- Neat cement slurry with  
% Bentonite
- K. Seal --- 2 ft  
Material --- 3/8" Bentonite pellets  
(hydrated)
- L. Gravel pack --- 10 ft  
Material --- Silica Sand, RMC Lonestar
- M. Second Seal --- 5 ft  
Material --- 3/8" Bentonite pellets  
(hydrated)
- N. Gravel Pack --- 5 ft  
Material --- Silica Sand, RMC Lonestar
- O. Depth to Groundwater --- 5 ft
- P. Steam Line --- 1-1/4" DIA  
20 ft from ground level
- Q. Steel Plate thickness --- 1/4 in  
depth from ground surface --- 18 ft  
Steel Plate is 4 inches apart
- R. Temperature Monitoring Well --- 25 ft  
6 pairs of thermocouples, each 4 ft apart

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Drawn by:	NAS Alameda
Approved by:	Figure 8.3
Date: 6/20/95	INJECTION/
Project: SEE Site 13	EXTRACTION WELL

T-TYPE THERMOCOUPLE TERMINAL  
BOX, WEATHERPROOF, 6 PAIRS OF  
CONNECTORS

GRADE LEVEL

~ 5 FT

2" OD CARBON STEEL  
SCH 40 PIPE

~ 8 FT

~ 25 FT

~ 4 FT

2" NPTF CAP

### Legend

THERMOCOUPLE BEAD

• T-TYPE, STAINLESS STEEL  
SHIELDED, 24 AWG W/TEFLON  
COATING

|| BUNDLE OF THERMOCOUPLE  
WIRES

NOTE: THE THERMOCOUPLE BEADS  
AND WIRES ARE ATTACHED OUTSIDE  
THE STEEL TUBING. ONE BEAD EVERY  
5 FEET

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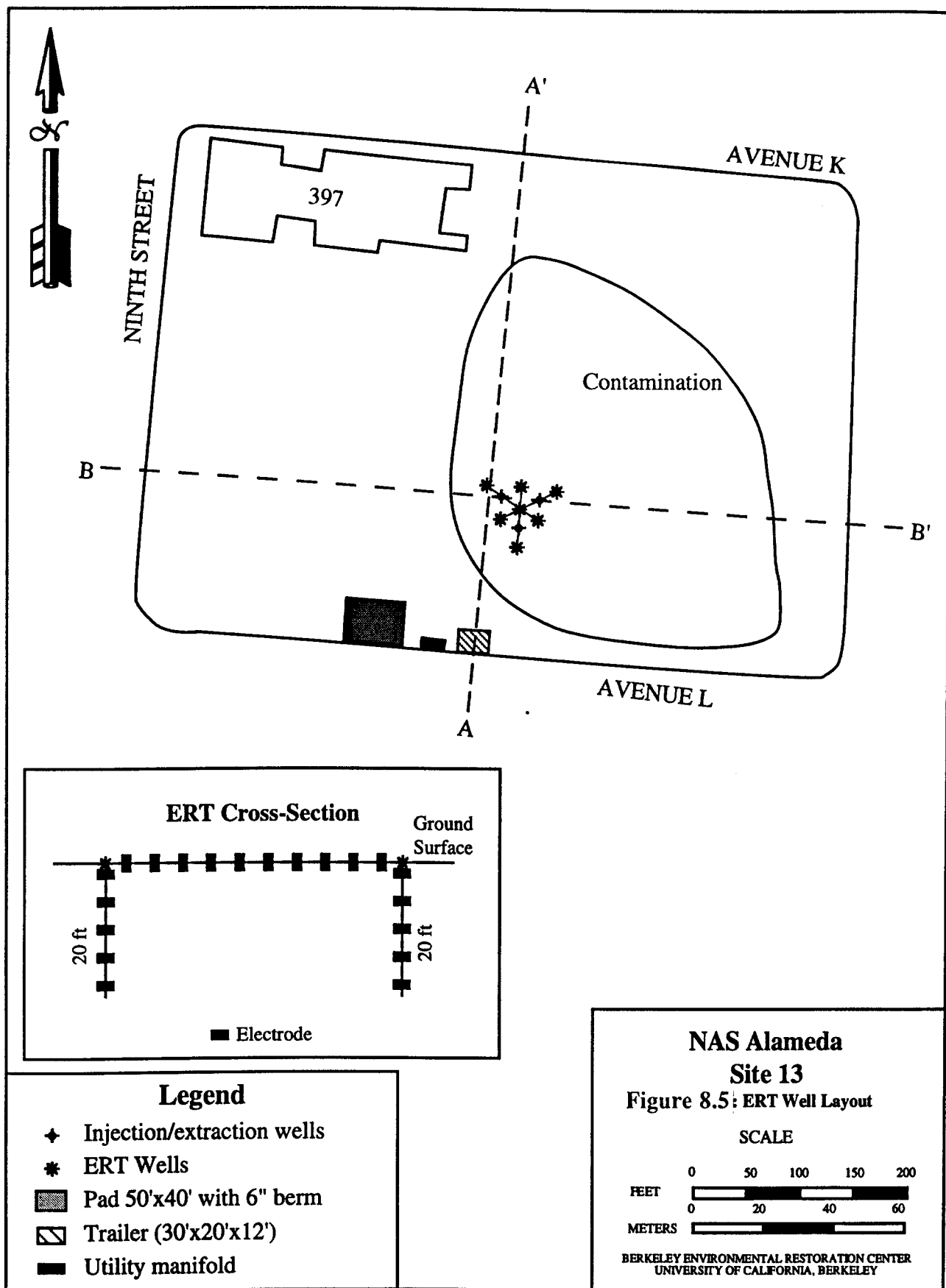
NAS Alameda

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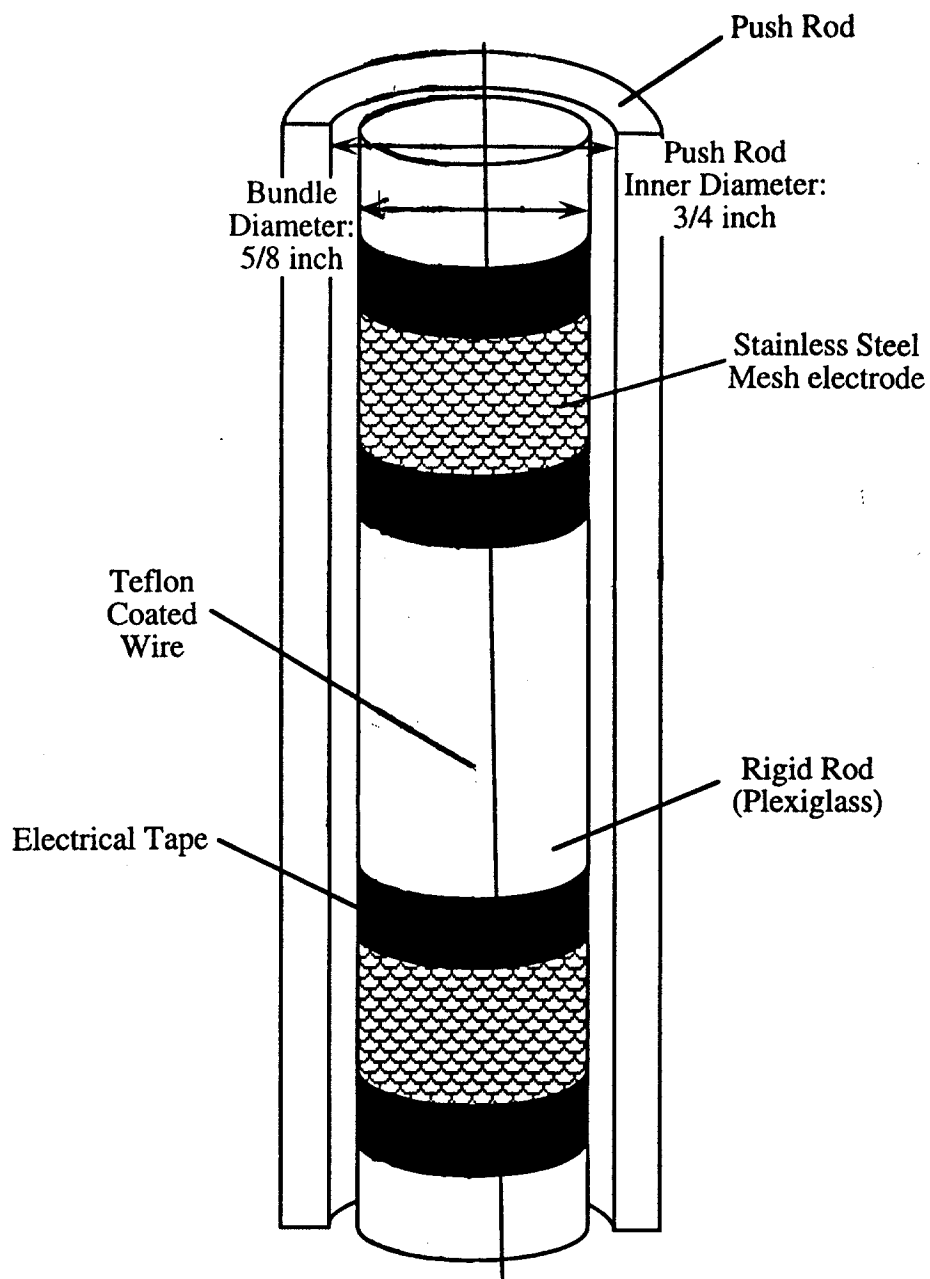
Figure 8.4  
TEMPERATURE  
MONITORING WELL

Date: 6/17/95

Project : SEE Site 13







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Drawn by:

NAS Alameda

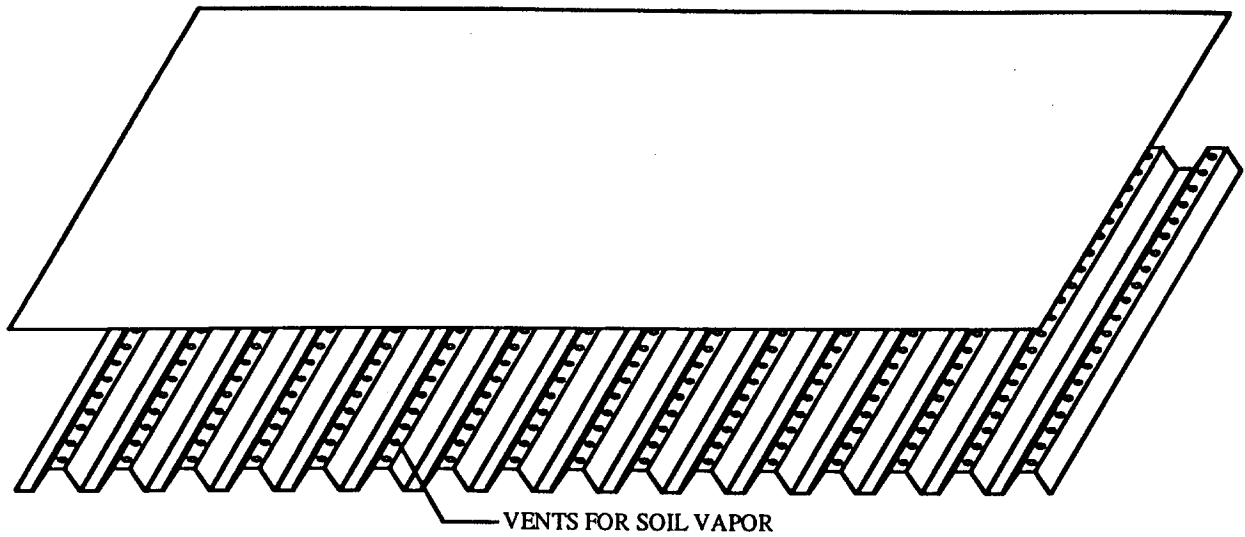
Approved by:

**Figure 8.6**  
Electrode/  
Thermocouple  
Schematic

Date: 6/22/95

Project : SEE Site 13

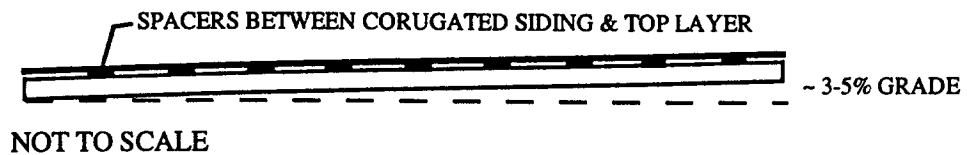
**PERSPECTIVE VIEW**



**FRONT VIEW**



**SIDE VIEW**



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Drawn by:

**NAS Alameda**

Approved by:

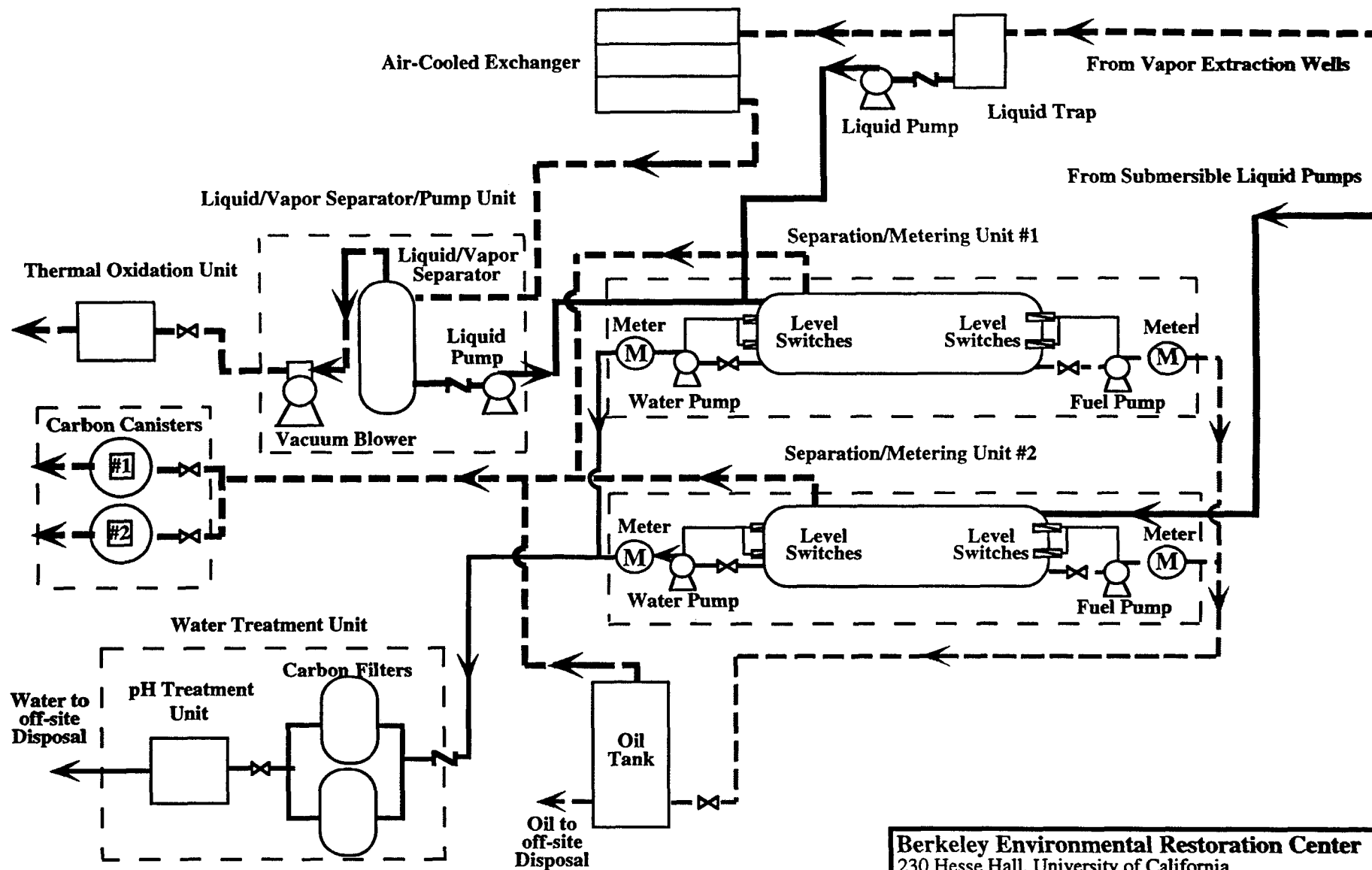
**Figure 8.7:**

Date: 4/17/95

**SURFACE**

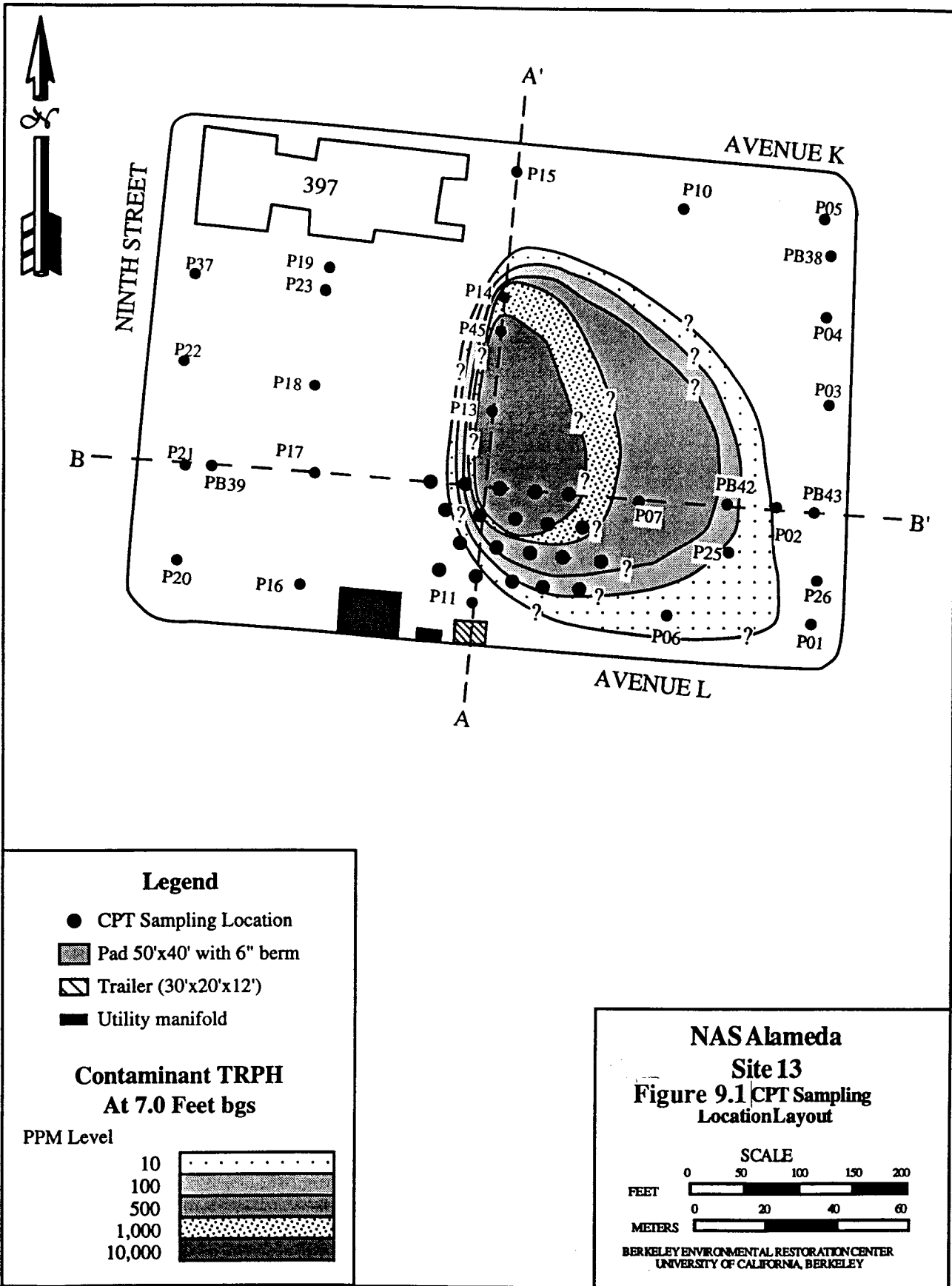
Project : SEE Site 13

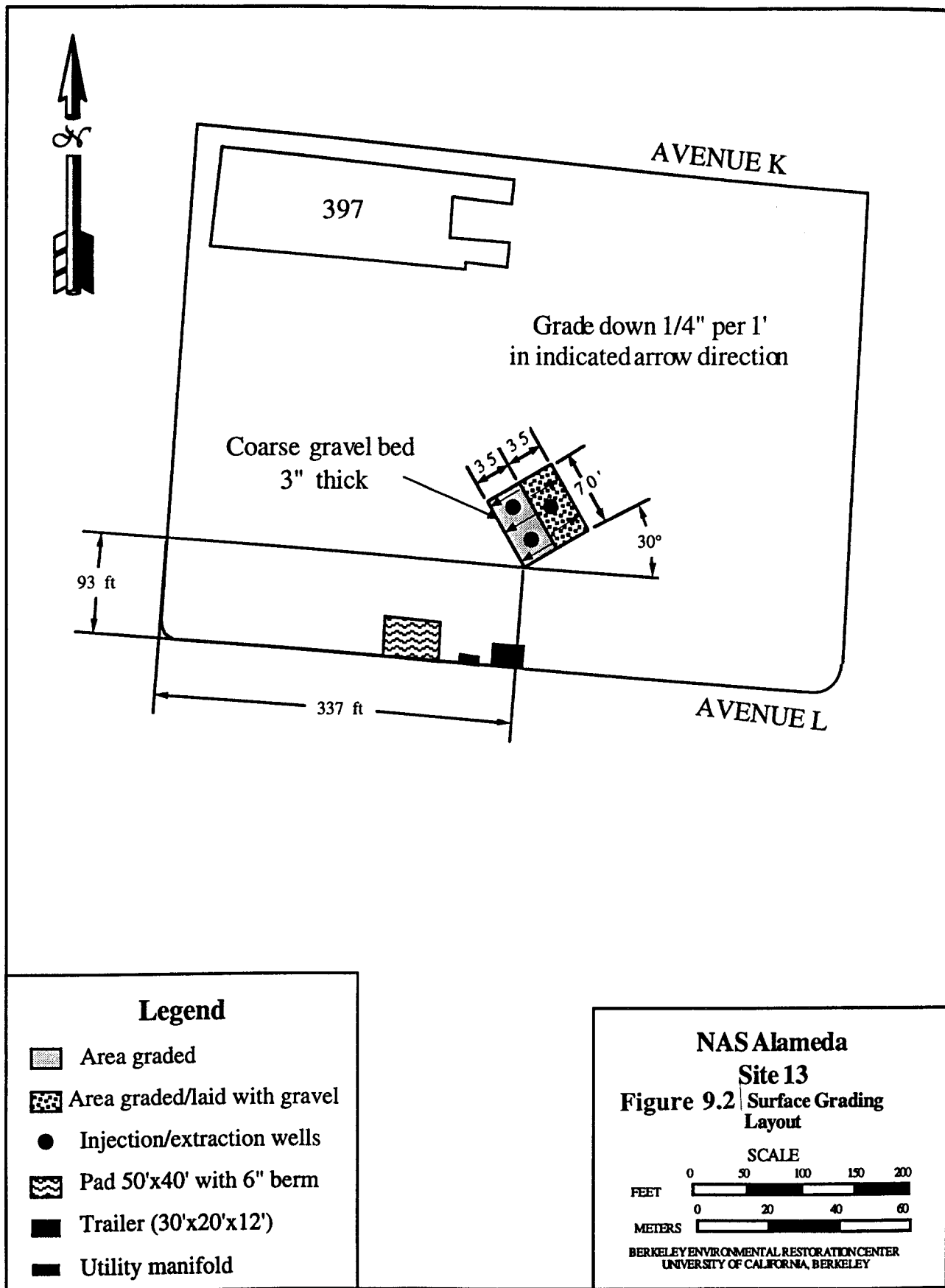
**COVERING DESIGN**



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Drawn by:	NAS Alameda
Approved by:	Figure 8.8
Date: 4/17/95	FLOW DIAGRAM
Project : SEE Site 13	





Required Documentation

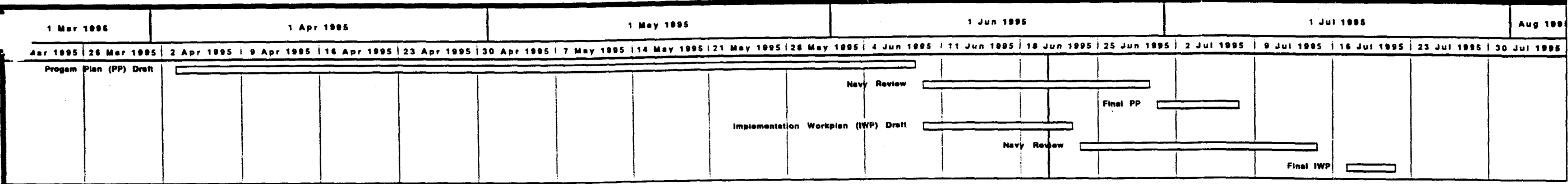


Figure 9.3  
Documentation Schedule

Treatability Study

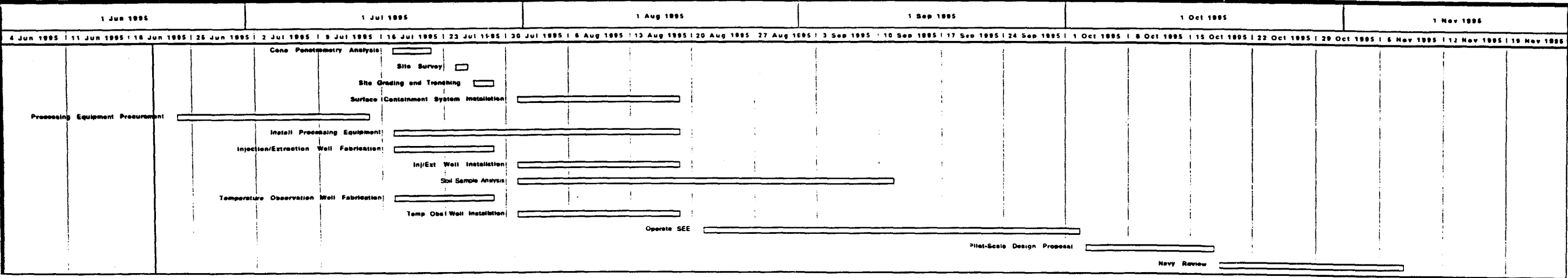


Figure 9.4  
Treatability Test Implementation Schedule

Pilot-Scale Study

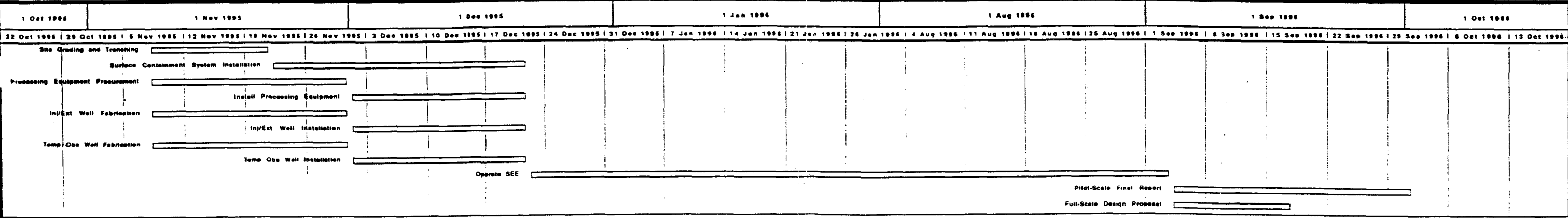


Figure 9.5  
Pilot Scale Implementation Schedule



# ORGANIZATION CHART - DELIVERY ORDER 003

Fast-Track Environmental Cleanup:  
A NAS Alameda - University of California Partnership

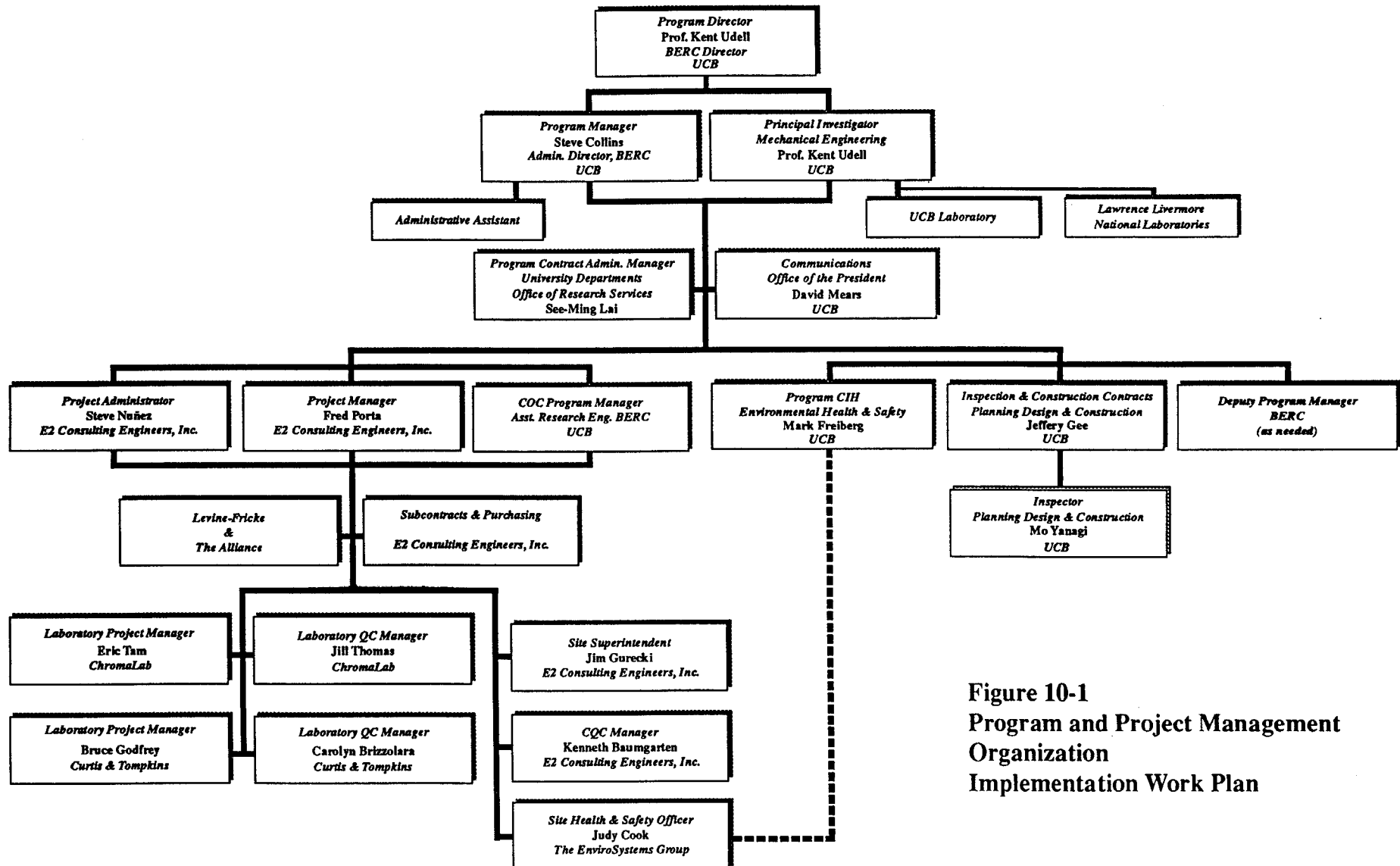


Figure 10-1  
Program and Project Management  
Organization  
Implementation Work Plan

## TABLES

**Table 9.1 Required Containers, Preservation Techniques, and Holding Times**

Analysis	Containers		Preservation	Maximum Holding Time
	Soil	Water		
BTEX	4 oz. jar	40 mL vial	< 4°C, pH<2 HCl	14 days
SVOC	4 oz. jar	1 L. amb. glass	< 4°C	7/40 days <sup>1</sup>
Metals	4 oz. jar	250 mL plastic	pH<2 HNO <sub>3</sub>	6 months
Mercury	4 oz. jar	251 mL plastic	pH<2 HNO <sub>3</sub>	28 days
Pesticides	4 oz. jar	1 L amb. glass	< 4°C, pH 5-9	40 days
Cyanide	4 oz. jar	1 L plastic	pH >12 NaOH	14 days
Oil & Grease	4 oz. jar	1 L glass	< 4°C, pH<2 HCl	28 days
pH	4 oz. jar	125 mL plastic	none req.	asap
TIC(volatile)	4 oz. jar	40 mL vial	< 4°C	14 days
TIC(semi-volatile)	4 oz. jar	1 L amb. glass	< 4°C	7/40 days
TTO(volatile)	4 oz. jar	40 mL vial	< 4°C	14 days
TTO (semi-volatile)	4 oz. jar	1 L amb. glass	< 4°C	7/40 days
TRPH	4 oz. jar	1 L glass	< 4°C, pH<2 HCl	28 days

<sup>1</sup> soil/water

**Table 9.2 Analytical Methods**

Analysis	Method number	
	Soil	Water
BTEX	8240	625
SVOC	8270	625
Metals	6010	6010
Mercury	7471	7470
Pesticides	8080	8080
Cyanide	9010	335
Oil & Grease	5520 e&f	5520 b&f
pH	9045	9040
TIC(volatile)	8240/826	624
TIC(semi-volatile)	8270	625
TTO(volatile)	8240/826	624
TTO (semi-volatile)	8270	625
TRPH	418.1	418.1

Table 9.3 Summary of Required Analyses

Activity	Analysis				
	TRPH	BTEX	PESTICIDES	SVOCS	Metals
Three Well Treatability Test					
Injection/extraction wells					
soil samples	9	9	9	9	9
groundwater samples	3	3	3	3	3
tripblanks	0	2	0	0	0
equipment rinsate	2	2	2	2	2
field blanks	2	2	2	2	2
field duplicates	1	1	1	1	1
Fifteen Well Pilot Scale Test					
Injection/extraction wells					
soil samples	36	36	36	36	36
groundwater samples	12	12	12	12	12
tripblanks	0	6	0	0	0
equipment rinsate	2	2	2	2	2
field blanks	2	2	2	2	2
field duplicates	1	1	1	1	1
Post-Steamming Sampling					
soil samples	35	35	35	35	0
groundwater samples	0	0	0	0	0
tripblanks	0	2	0	0	0
equipment rinsate	1	1	1	1	0
field blanks	2	2	2	2	0
field duplicates	0	0	0	0	0

Table 9.4 Operational monitoring Frequency

Sample Type	Frequency
Temperature (from the temperature monitoring wells)	twice daily
Flow rate	twice daily
Pressure	twice daily
Influent and Effluent Sampling	daily <sup>1</sup>
Electrical Resistivity	weekly

<sup>1</sup> Frequency to be revised after one week of sampling.  
Analyses are specified in Section 9.3.6.1.

**Table 9.5**  
**DISCHARGE LIMITATIONS**

<b>Regulated Parameter</b>	<b>Daily Maximum</b>
Arsenic	2 mg/L
Cadmium	1 mg/L
Chromium	2 mg/L
Copper	5 mg/L
Cyanide (Total)	5 mg/L
Iron	100 mg/L
Lead	2 mg/L
Mercury	0.05 mg/L
Nickel	5 mg/L
Oil and Grease	100 mg/L
pH (not less than)	5.5 S.U.
Phenolic Compounds	100 mg/L
Silver	1 mg/L
Temperature	150 ° F (65.5° C)
Total Identifiable Chlorinated Hydrocarbons	0.5 mg/L
Zinc	5 mg/L
Total Toxic Organics	2.13 mg/L

Fast-Track Environmental Clean-up:  
A NAS Alameda - University of California Partnership  
Contract Nbr.: N62474-94-D-7420

Delivery Order 003: Steam Enhanced Extraction at Site 13

**PILOT-SCALE TREATABILITY WORK PLAN**

**APPENDIX A:**

**LABORATORY TREATABILITY TEST ANALYTICAL  
RESULTS**

Prepared by

Professor Kent S. Udell  
Celia Alcantar  
Michael Itamura  
Robert McCarter  
Berkeley Environmental Restoration Center

for

EFA WEST (Code 0222)  
Naval Facilities Engineering Command  
900 Commodore Drive  
San Bruno, CA 94066-5006

Unclassified  
August 5, 1995

DRAFT



## **SEE LABORATORY TREATABILITY TEST ANALYTICAL RESULTS**

### **INTRODUCTION**

Previous laboratory treatability tests of the applicability of SEE to relatively low volatility hydrocarbon mixtures such as JP-5 fuel and coal tars conducted at the University of California, Berkeley in the BERC laboratory showed effective removal of those liquid compounds from soils. There are questions whether SEE would be effective in removing the waste oil from the Site 13 soils since the oil may be distillation column residues and consists of very low volatility components. If this is the case, then steam distillation would not be cost effective for complete removal. The potential extent of removal of the toxic components of the waste oil from Site 13 soils by SEE, and the composition of the residual hydrocarbons are of interest, however, since reductions in the concentrations of the most volatile compounds may be enough to reduce potential health risks to acceptable values. Furthermore, the acidic conditions at the site and metal stability may be positively affected by the steaming process.

To better define the characteristics of the effluent liquids and residual waste oil, a laboratory treatability test was conducted. The apparatus, sample preparation procedures, steam injection schedule, and soil and effluent chemical analyses for the laboratory experiment are presented below. An energy cost analysis is presented to show that complete restoration of the site by steam distillation would be cost prohibitive, and modest hydrocarbon recovery may be obtained at for energy costs in the range of \$20/yd<sup>3</sup>. Further laboratory treatability tests with significantly less steam throughput volumes are recommended.

### **ONE-DIMENSIONAL EXPERIMENTAL APPARATUS**

As shown in Figure A.1, the apparatus for the one-dimensional treatability experiment consisted of a pair of metering pumps to deliver a constant mass flow rate of distilled water, a steam generator to boil the water into steam, a stainless steel pipe to hold the contaminated soil sample, and an effluent collection jar maintained in an ice bath to minimize loss of components from the effluent to the atmosphere.

## SEE TREATABILITY TEST RESULTS

The inlet and outlet of the sample holder had end caps which could be unbolted and removed to pack and unpack the soil sample. These caps had channels cut on their inner surface in contact with the soil to help spread the injected steam across the entire inlet cross section of the sample holder and reduce the end effects of the one-dimensional experiment. In addition to these channels, three-hundred and twenty-five mesh stainless steel screens were attached to the inner surfaces of the end caps to encourage uniform spreading of the steam over the sample holder cross section and to prevent the grains of soil in the sample from escaping the sample holder.

The stainless steel sample holder was wrapped with heater tape and insulated. During injection, this heater tape was set to a constant supply power to offset the heat loss through the insulation, maintaining a constant temperature along the length of the tube and thus producing an adiabatic environment. Thermocouples were mounted at the steam inlet tubing, the upstream end of the soil sample, the downstream end of the soil sample, and the outlet tubing. Teflon tubing was used to carry all fluids into and out of the system. The outlet tubing was long enough to allow the effluent to cool to near room temperature before it entered the effluent collection bottle. Because flow rates were low, usually one meter (3.3 feet) of tubing was a sufficient length.

When the effluent flow rate was too high to condense all of the steam in the effluent tube, a condenser stage was added to the outlet tubing between the outlet of the stainless steel piping and the effluent collection jar.

## SOIL SAMPLE PREPARATION

Soils were taken from contaminated regions of Site 13 using a hand auger. The soil was chilled to reduce hydrocarbon vapor pressures and mixed in a clean Pyrex tray to uniformly distribute the waste oil throughout the sample. One sample was sent to an outside laboratory for analysis for total extractable hydrocarbon (TEH) concentrations, polyaromatic hydrocarbon (PAH) concentrations, and metal concentrations.

Contaminated soils were packed into the stainless steel sample holder by alternately adding a few centimeters of soil and compacting with a large wooden dowel to reduce void spaces in the pack. The thermocouples situated within the soil were inserted during packing. Packing continued until enough material was in the sample holder to require slightly

## SEE TREATABILITY TEST RESULTS

compressing the end cap when it was bolted into place. This compression minimized the voids created during settling of the sand pack. Such voids were undesirable since they compromised the homogeneity of the one-dimensional sand pack and may lead to uneven steam flow.

### STEAM INJECTION PROCEDURE

After packing the sample holder with contaminated soil as described in the sample preparation section, the metering pumps were set to provide a constant water flow rate of 38 ml/hr. Previous experiments on tarry compounds more volatile than those suspected at Site 13 show that a contaminant level of 10,000 mg/kg can be removed to a level exceeding 99% in about two weeks. Based on these results, we expected to conduct the treatability tests for two to three weeks depending on effluent fluid characteristics. If the effluent liquid had no visible liquid hydrocarbon as floating product or emulsion, and the effluent had no odor, the experiment would be concluded. Since the contaminant concentrations removed by steam were highest during the first part of injection, sampling was more frequent in the early stages of the experiment in order to have better resolution of initial contaminant removal. All of the effluent coming from the sample holder was collected into sample bottles according to the following regime:

Table A.1. Sampling Schedule

Begin Injection	Sample Time (day)	Cumulative Time (day)
Sample 1	0.04	0.04
Sample 2	0.04	0.08
Sample 3	0.04	0.13
Sample 4	0.04	0.17
Sample 5	0.04	0.21
Sample 6	0.12	0.33
Sample 7	0.17	0.50
Sample 8	0.17	0.66
Sample 9	0.17	0.83
Sample 10	0.34	1.17
Sample 11	0.33	1.50
Sample 12	0.35	1.85
Sample 13	0.31	2.16

SEE TREATABILITY TEST RESULTS

Sample 14	0.52	2.67
Sample 15	0.48	3.15
Sample 16	0.52	3.67
Sample 17	0.49	4.16
Sample 18	1.00	5.16
Sample 19	1.00	6.16
Sample 20	1.00	7.16
Sample 21	1.00	8.16
Sample 22	1.00	9.16
Sample 23	1.00	10.16
Sample 24	1.00	11.16
Sample 25	1.00	12.16
Sample 26	1.00	13.16
Sample 27	1.04	14.20
Sample 28	1.06	15.26
Sample 29	9.82	25.08
Sample 30	1.02	26.10
Sample 31	1.04	27.14
Sample 32	1.00	28.14
Sample 33	1.02	29.16
Sample 34	0.72	29.88
Sample 35	1.06	30.95
Sample 36	0.99	31.93
Sample 37	1.01	32.94
Sample 38	1.00	33.94
Sample 39	1.04	34.97
Sample 40	1.05	36.03
Sample 41	0.96	36.99
Sample 43	0.95	37.94
Sample 44	1.00	38.94
Sample 45	0.99	39.93
Sample 46	0.97	40.90
Sample 47	1.05	41.95
Sample 48	0.97	42.92
Sample 49	1.00	43.92
Sample 50	1.02	44.94
Sample 51	0.99	45.94

While this regime provided small samples of effluent allowing detailed analysis of effluent concentrations during the first few hours of injection, it gave large samples of effluent later in the experiment when

## SEE TREATABILITY TEST RESULTS

concentrations were low and changing slowly. To minimize sample degradation, an ice bath surrounded each bottle while collecting the effluent. As each bottle filled, it was sealed with a Teflon cap and placed in a refrigerator at 4 °C ( $\pm 2$  °C) or an ice bath to prepare for transport to the analytical laboratory.

The pressure in the sample holder was cycled throughout the injection using a timer on a solenoid valve at the outlet end of the sample holder. The valve functioned to close the outlet for one hour and open it for thirty minutes while maintaining steady steam flow into the inlet. With the valve closed steam pressures rose to 207 kPa gage (30 psig). Then the valve was opened to depressurize the system over about two minutes. Cycling in this way first increased the pressure and temperature of contaminants in the sand pack and then caused the contaminants to vaporize as the ambient pressures returned to normal. This process increased the contaminant concentrations in the effluent by mobilizing contaminant trapped in less accessible regions such as crevices between sand grains. During steam cycling, the effluent tube was placed in an ice bath to condense the effluent before it reaches the sample bottle.

On the sixteenth day of steaming, the steam generator developed a leak. The experiment was temporarily shut down and the test cell was flooded with water, capped and refrigerated. While the steam generator was being repaired, the test cell remained in the refrigerator for a period of nine days. When the cell was removed, a leachability study was performed. Water which had been placed in the test cell and allowed to equilibrate with the residual contaminants was flushed out using nitrogen gas. Sample 29 consisted of this collected effluent. Steaming resumed with Sample 30.

## QUALITY ASSURANCE/QUALITY CONTROL

The one dimensional bench study followed the quality assurance and quality control procedures outlined in the Quality Assurance/Quality Control Plan. In addition, all water injected into the sample holder was distilled and then boiled to reduce the amount of dissolved gas. All tubing used to carry the water and effluent was made of Teflon in order to avoid contamination by interaction with the tube material. To minimize the chance of system contamination, the system remained closed throughout the experiment except for the necessary introduction of water to the metering pumps and the changing of the sample bottles.

## SEE TREATABILITY TEST RESULTS

All sample bottles were prepared by washing with nonphosphate detergent followed by multiple tap water and distilled water rinses. After washing, the bottles were oven-dried and sealed with Teflon caps. Sample bottles were kept in an ice bath while the effluent was being collected to keep the temperature low and minimize potential losses due to evaporation. Filled sample bottles were capped with a Teflon cap and placed in either a refrigerated space or into a cooler containing ice to maintain temperatures at 4 °C ( $\pm 2$  °C).

Each cooler contained a method blank consisting of distilled water from the same source as that used in the metering pumps. The method blank should have indicated any contamination in the preparation, storage, and transportation of the samples. All samples were packed with foam and ice prior to transportation. All samples were sent for analysis within the prescribed holding time. Each cooler contained a chain of custody form and was sealed with custody tape.

## LABORATORY SAMPLE ANALYSIS

The soil and effluent samples were sent to Curtis and Tompkins, Ltd. Analytical Laboratories (Berkeley, CA) for chemical analysis. The soil samples taken from the site were analyzed for TEH (EPA method 8015), PAH (EPA method 8270) and metals (EPA method 6010). Effluent samples were analyzed for TEH (EPA method 8015), PAH (EPA method 8270) and pH (EPA 9040). Table A.2 below summarizes the samples analyzed and the methods employed.

Table A.2. Samples Analyzed and Methods Employed

	TEH (Method 8015)	PAH (Method 8270)	Metals (Method 6010)	pH (Method 9040)
Original Soil	√	√	√	
Post-Steam Soils #1-9	√		√	
Effluent #1	√			√
Effluent #2-41,43-50	√			
Effluent #51	√			√

## **RESULTS**

### **Untreated Soil Analytical Results**

The untreated soil was heavily contaminated with crude oil-like petroleum hydrocarbons in concentrations of 32,000 ppm in the diesel and motor oil range. Longer and shorter chained hydrocarbons outside of the diesel and motor oil range are not included in the analysis, and thus the actual concentration was larger. As shown in the Method 8015 chromatogram (Figure A.2) and the Method 8270 chromatogram (Figure A.3), the distribution of hydrocarbons is spread from retention times of 5 min. to 30 min., which corresponds to straight-chain hydrocarbons from C14 to C44 (see Figure A.4: carbon range standard, Figure A.5: diesel standard, Figure A.6: motor oil standard).

The PAH analysis (EPA Method 8270) showed all compounds of concern to be below detection limits; however the detection limits of individual components were quite high (50 ppm to 250 ppm). Thus, no conclusions can be drawn regarding the presence or absence of compounds of health concern.

The metal analysis (EPA Method 6010) showed moderate levels of Chromium (20 mg/kg), Copper (110 mg/kg), Lead (38 mg/kg), Nickel (21 mg/kg), and Zinc (57 mg/kg).

### **Post-Steam Soil Analytical Results**

While there was a dramatic compositional change in the waste oil after being subjected to steam flow, the actual concentrations remained high in the motor oil range as shown in Table A.3. The location of each sample is referenced to the distance from the test cell outlet.

Table A.3. Soil Hydrocarbon Concentrations

LAB ID	Sample ID	Diesel Range (mg/kg)	Motor Oil Range (mg/kg)
121413-001	S0	12,000	20,000
121413-002	S1@1"	1,600	25,000
121413-003	S2@2"	1,500	30,000
121413-004	S3@3"	490	30,000
121413-005	S4@4"	ND(300)	23,000
121413-006	S5@5"	ND(400)	12,000
121413-007	S6@6"	ND(930)	21,000
121413-008	S7@7"	ND(930)	35,000
121413-009	S8@8"	ND(1,900)	33,000
121413-010	S9@9"	ND(880)	36,000

The chromatograms for the steam soil (Figures A.7-A.15) show interesting trends of the preferential removal of the shorter retention time hydrocarbons (more volatile) and anomalous peaks in the 14 min. to 18 min. range near the inlet and outlet of the test cell (S9 and S1). These peaks are presumed to be due to vapor fluxes inside the test cell due to heat losses at the endcaps.

The metal analysis (EPA Method 6010) of all soils, presented in Table A.4, showed no appreciable change in the levels of Beryllium, Cadmium, Chromium, Copper, Lead, or Nickel. Mercury was detected in the untreated soil, but not in the treated soils. Since mercury is a relatively volatile metal, its removal, and thus presence in extracted fluids, is expected. Arsenic and Zinc concentrations may also have been reduced by the steaming process.

Table A.4. Soil Metals Concentrations

	Arsenic (mg/kg)	Beryllium (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)
S0	1.50	0.16	0.3	20	110	38	0.13	21	57
S1@1"	0.80	0.13	0.33	20	94	60	ND(0.4)	21	49
S2@2"	0.69	0.15	0.33	21	38	0	ND(0.1)	20	33
S3@3"	0.82	0.13	0.3	18	75	100	ND(0.1)	20	18
S4@4"	0.67	0.14	0.32	21	130	70	ND(0.1)	21	22
S5@5"	0.77	0.13	0.29	19	130	61	ND(0.1)	20	19
S6@6"	1.00	0.15	0.3	21	110	72	ND(0.1)	22	26
S7@7"	0.99	0.14	0.28	21	54	55	ND(0.1)	21	32
S8@8"	0.83	0.14	0.33	24	49	83	ND(0.1)	21	33
S9@9"	0.83	0.15	0.38	25	42	71	ND(0.1)	21	32



### **Effluent Liquid Analyses**

The effluent analyses results (EPA Method 8015) are summarized in Table A.4. The concentrations are highest in the first 12 samples, and decrease significantly thereafter. Also reflected in these numbers is the trend of increasing retention times of the hydrocarbons found in the effluent with the time of steaming. This trend shows up in the shift from compounds in the diesel range to the longer retention time motor oil range. The numbers reported, while self-consistent, are not fully representative of the effluent concentrations due to the limited range of the diesel and motor oil standards.

SEE TREATABILITY TEST RESULTS

A.4. Effluent Analyses

LAB ID	Sample ID	Diesel Range (mg/kg)	Motor Oil Range (mg/kg)
121433-001	E-1	23	ND(16)
121433-002	E-2	3,400	ND(1,300)
121433-003	E-3	110	ND(16)
121433-004	E-4	33,000	ND(3,100)
121433-005	E-5	2,100	ND(300)
121433-006	E-6	2,100	ND(250)
121433-007	E-7	3,200	ND(830)
121433-008	E-8	1,500	ND(180)
121433-009	E-9	1,700	ND(170)
121433-010	E-10	6,600	ND(830)
121433-011	E-11	2,200	ND(480)
121433-012	E-12	4,800	ND(480)
121433-013	E-13	80	ND(13)
121433-014	E-14	180*	ND(57)
121433-015	E-15	560*	ND(150)
121433-016	E-16	220*	ND(140)
121433-017	E-17	340*	56*
121433-018	E-18	230*	300*
121433-019	E-19	110*	120*
121433-020	E-20	65*	46*
121433-021	E-21	68*	49*
121433-022	E-22	51*	39*
121433-023	E-23	48*	36*
121433-024	E-24	34*	30*
121433-025	E-25	29*	63*
121433-026	E-26	23*	22*
121433-027	E-27	19*	17*
121433-028	E-28	38*	25*
121433-029	E-29	4.1*	ND(16)
121433-030	E-30	18*	16*
121433-031	E-31	42*	27*
121433-032	E-32	18*	16*
121433-033	E-33	8.8*	15*
121433-034	E-34	14*	29*
121433-035	E-35	8.8*	36*
121433-036	E-36	7.9*	39*
121433-037	E-37	6.4*	30*
121433-038	E-38	4.8*	37*
121433-039	E-39	4.5*	37*
121433-040	E-40	4.7*	44*
121433-041	E-41	3.8*	39*
121433-042	E-43	9.2*	60*
121433-043	E-44	4.1*	35*
121433-044	E-45	14*	29*
121433-045	E-46	0.92*	29*
121433-046	E-47	1.2*	25*
121433-047	E-48	1.1*	24*
121433-048	E-49	1.1*	23*
121433-049	E-50	2.3*	40*
121433-050	E-51	2.2*	23*

\*Sample chromatogram does not resemble hydrocarbon standard.

## SEE TREATABILITY TEST RESULTS

The chromatograms corresponding to the analyses presented in Table A.4 are summarized in Figure A.16, while the individual chromatograms are presented in Figures A.17 - A.66. Figure A.16 is a three-dimensional representation of the detector response as a function of retention time for each analyses, stacked in depth to show trends with respect to sample number (time). Figure A.16 clearly shows the shift in composition with sample number from shorter retention time components at the beginning, to longer-chained, greater retention time compound at the later stages of the treatability test. It is also clear from this plot that the bulk of the recovered hydrocarbon mass was removed during the first fraction of the experiment.

### Cumulative Mass Removed

The cumulative mass removed was calculated by multiplying the total concentrations of hydrocarbons (diesel range plus motor oil range values) by the total mass of liquid in the effluent sample, and summing all sample hydrocarbon mass values. The cumulative mass removed was thus found to be 9 grams. The trend with cumulative steam condensate recovered is plotted in Figure A.67. As shown in Figure A.67, most of the hydrocarbon mass was removed during the first fifth of the experiment. Thereafter, the mass removal rate was small due to the low volatility of the compounds remaining in the soil. It is of note that the removal rates during the later parts of the experiment were comparable to those that might be expected during isothermal groundwater pumping.

### pH Analyses

pH analyses were performed on E-1 and E-51. Since the volume of water drained from the test column after 9 days of refrigeration (E-29) was small, insufficient water was available to perform EPA Method 9040. Enough water was available to test pH using litmus paper however, and that value is presented in the following table along with those of E-1 and E-51.

Table A.6. pH of Effluent Fluid

Sample ID	pH
E-1	2.1
E-29	6-7*
E-51	6.3

\*value obtained from litmus test

## SEE TREATABILITY TEST RESULTS

From these analyses, it appears that the steaming process increases the pH of the water in equilibrium with the waste oil for very acid conditions to neutral values. This pH neutralization seems to occur early in the steaming process than later.

## ENERGY COST ANALYSIS

The result of the treatability test show decreasing recovery rates with time as the more volatile compounds are first removed and the less volatile compounds remain. Extrapolation of the data and trends to extremely long times indicates that a substantial fraction of the hydrocarbon mass may be removed, but at the cost of very large steam volumes. To bring these results to a form appropriate for field-scale evaluation, the steam condensate mass is normalized to the test cell pore volume, defined as the internal volume of the test cell multiplied by the soil porosity. Since the porosity of the highly contaminated soil could not be measured, it is assumed to be 40% for the purpose of analysis. The fraction of the initial hydrocarbon mass that was removed during the steaming process was calculated from the mass of hydrocarbon remaining in the soils after steaming plus the total mass of hydrocarbon removed during the steaming process since the original concentration of hydrocarbons in the unsteamed soil is considered to be less reliable than the post-steaming concentrations or cumulative hydrocarbon mass removed. From the calculation of the initial mass, the hydrocarbon concentration in the unsteamed soil is estimated to be 45,000 mg/kg. A plot of the fraction of original hydrocarbon mass removed vs. the number of pore volumes of steam condensate collected is provided in Figure A.68. Note that Figure 67 and 68 have the same basic shape. Since the steam distillation rate drops off exponentially for long-term steam distillation, the fraction of oil removed for condensate pore volumes greater than 20 will not vary significantly from those shown for soil concentrations less than 50,000 mg/kg.

The energy cost per unit volume of soil for the steaming process is proportional to the pore volumes of steam injected which is linearly related to the pore volumes of steam condensate. The costs can thus be calculated from the following equation which was derived from a energy and mass balances.

$$$/yd^3 = \$/MBtu \times (\text{pore volumes condensate}) \times .7555$$

The factor .7555 is the porosity (0.4) multiplied by the water density (62.3 lbm/ft<sup>3</sup>) multiplied by the difference between the steam enthalpy and the

## SEE TREATABILITY TEST RESULTS

inlet water enthalpy ( $1.1228 \times 10^{-3}$  MBtu/lbm), and the conversion factor between cubic feet and cubic yards ( $27 \text{ ft}^3/\text{yd}^3$ ).

Using the equation above, the energy cost associated with a given fraction of hydrocarbon recovery can be obtained from the data of Figure A.69. The analysis was performed for two energy costs, one with quoted steam costs at Alameda (\$13.52/Mbtu) and the other for field SEE operation at LLNL during the summer of 1993 (\$2.5/Mbtu). Figure A.69 can be used to estimate the expected cost for recovering a specified fraction of the hydrocarbon mass from soil contaminated with oil at a concentration of 45,000 mg/kg. As shown in the figure, 25% of the oil mass can be removed for about \$20/yd<sup>3</sup> in energy cost if commercial rates for an energy source are paid. However, Alameda steam costs would be over \$100/yd<sup>3</sup> for the same level of removal.

While this analysis is based on the composition and assumed concentration of the oil in this single soil sample, its implications are clear. First, complete removal of the hydrocarbon phase from this site by steam distillation would be prohibitively expensive. Second, mobilization and capture of the liquid oil will be much more effective in removing oil mass than steam distillation. Third, if pH reduction is considered to be a priority function of the in situ cleanup of this site, then steam injection of relatively short duration may be valuable. Indeed, the expectedly low pH of site water may be responsible for the very small microbial populations observed in the oil-free soils sampled thirty feet from the location of the hydrocarbon laden soil used in these treatability tests. Thus pH reduction maybe necessary before biodegradation reactions can occur to any significant extent.

## CONCLUSIONS

Based on this laboratory treatability test, Steam Enhanced Extraction alone will not be capable of removing the low-volatility components of the waste oil without exorbitant energy costs. Up to 25% of the waste oil may be removed from the soil for a commercial energy cost of \$20/ yd<sup>3</sup> of treated soil. SEE does have the ability to restore the soil water to neutral pH from an initial effluent sample pH of 2.1, and reduced the aqueous phase hydrocarbon concentrations by a factor of 5.6 at a point half way through the treatability test.

## **RECOMMENDATIONS**

While the results of this treatability test were not entirely positive, the information gleaned from the study has been very valuable in knowing the limits of field performance, both economic and effectiveness. Within those limits, there is much value to be gained in the restoration of this site through the application of SEE. Particularly, the removal of the most volatile fraction of the hydrocarbon mass, and the restoration of the site to neutral pH may be possible at modest cost. These changes may have sufficient effect on contaminant mobility and future hydrocarbon biodegradation rates to allow the process to meet cleanup needs without further processing. Thus, it is recommended that an additional short duration treatability test be run to assess the effect of SEE on the leachability of the hydrocarbons and PAH's, if present, and the pore water pH. These tests are to be run in accordance with the Laboratory Treatability Study section of this work plan, with modifications as specified in the following section.

## **AMENDMENTS TO LABORATORY TREATABILITY WORK PLAN**

After the contaminated soils are placed in the core-holder and before steam injection begins, the core-holder will be flooded with distilled, de-ionized and de-aerated water, and sealed. After a period of 5 days to allow thermodynamic equilibrium conditions to become established, the water will be drained from the core-holder, split into two samples, and sent to two independent analytical laboratories to assess for total petroleum hydrocarbon concentrations (against crude oil, diesel, and motor oil standards), PAH concentrations, pH, and metal concentrations. These analysis will be used as the baseline for the assessment of the leachability of the contaminants from the affected soils.

Steam will be injected for a period of 50 hours allowing for 10 pore volumes of steam condensate and displaced water to be collected in 10 effluent sample containers.

At the end of the steam injection treatability study, the core-holder will be slowly cooled to ambient temperature, and again flooded with distilled, de-ionized and de-aerated water. After a period of 5 days to allow thermodynamic equilibrium conditions to again become established, the water will be drained from the core-holder, split into two samples, and sent to two independent analytical laboratories to assess for total petroleum

## SEE TREATABILITY TEST RESULTS

hydrocarbon concentrations (against crude oil, diesel, and motor oil standards), PAH concentrations, pH, and metal concentrations. The comparison between the pre-steam and post-steam concentrations of the various compounds of concern in the drained water will provide a direct measure of the impact of steam injection on the reduction of the mobility of potentially toxic compounds, and thus the degree of reduction of risk of future exposure through groundwater pathways.

## SEE LABORATORY TREATABILITY TEST ANALYTICAL RESULTS

### INTRODUCTION

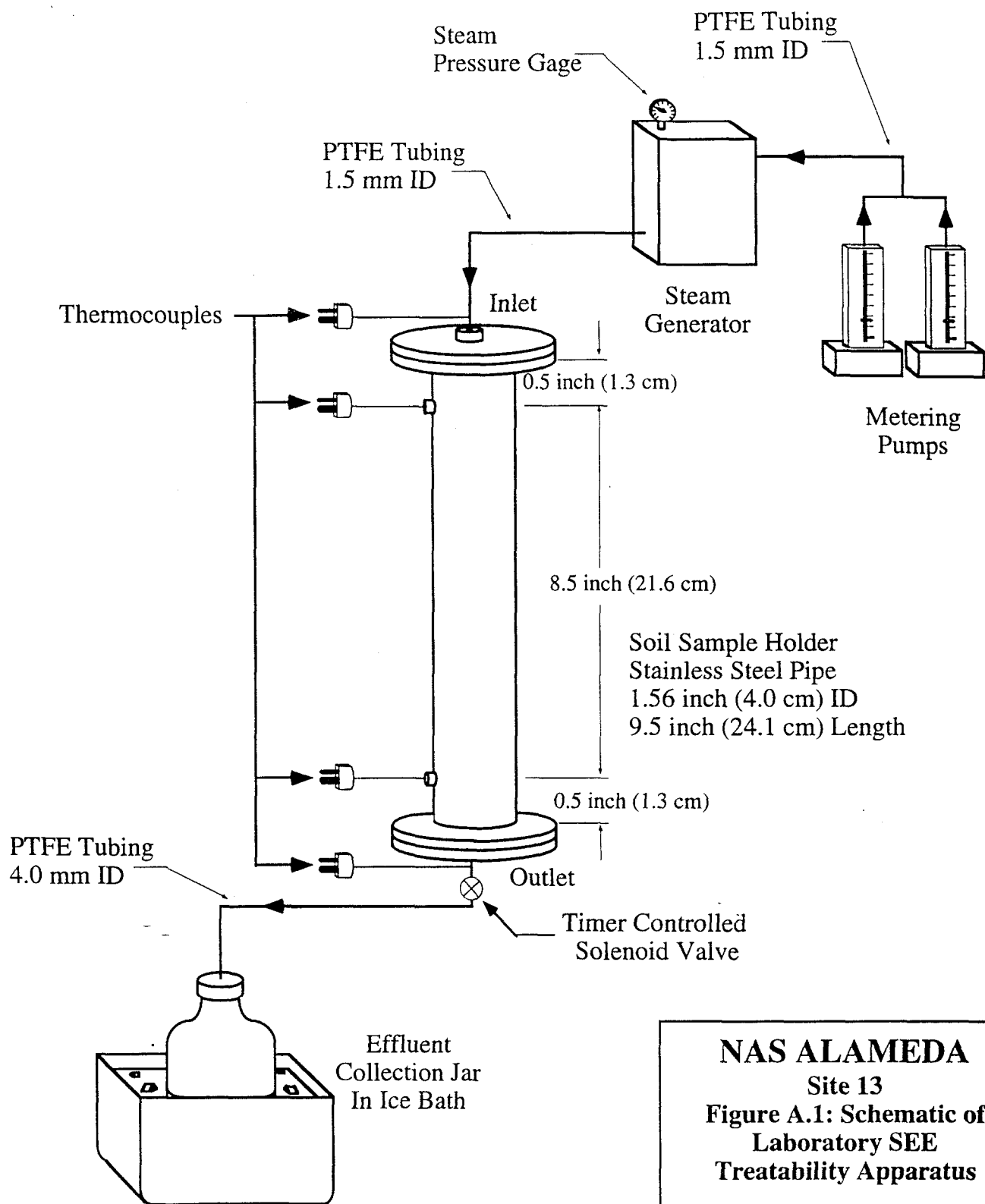
Previous laboratory treatability tests of the applicability of SEE to relatively low volatility hydrocarbon mixtures such as JP-5 fuel and coal tars conducted at the University of California, Berkeley in the BERC laboratory showed effective removal of those liquid compounds from soils. There are questions whether SEE would be effective in removing the waste oil from the Site 13 soils since the oil may be distillation column residues and consists of very low volatility components. If this is the case, then steam distillation would not be cost effective for complete removal. The potential extent of removal of the toxic components of the waste oil from Site 13 soils by SEE, and the composition of the residual hydrocarbons are of interest, however, since reductions in the concentrations of the most volatile compounds may be enough to reduce potential health risks to acceptable values. Furthermore, the acidic conditions at the site and metal stability may be positively affected by the steaming process.

To better define the characteristics of the effluent liquids and residual waste oil, a laboratory treatability test was conducted. The apparatus, sample preparation procedures, steam injection schedule, and soil and effluent chemical analyses for the laboratory experiment are presented below. An energy cost analysis is presented to show that complete restoration of the site by steam distillation would be cost prohibitive, and modest hydrocarbon recovery may be obtained at for energy costs in the range of \$20/yd<sup>3</sup>. Further laboratory treatability tests with significantly less steam throughput volumes are recommended.

### ONE-DIMENSIONAL EXPERIMENTAL APPARATUS

As shown in Figure A.1, the apparatus for the one-dimensional treatability experiment consisted of a pair of metering pumps to deliver a constant mass flow rate of distilled water, a steam generator to boil the water into steam, a stainless steel pipe to hold the contaminated soil sample, and an effluent collection jar maintained in an ice bath to minimize loss of components from the effluent to the atmosphere.





**NAS ALAMEDA**  
**Site 13**  
**Figure A.1: Schematic of**  
**Laboratory SEE**  
**Treatability Apparatus**

BERKELEY ENVIRONMENTAL RESTORATION CENTER  
 UNIVERSITY OF CALIFORNIA, BERKELEY

Sample Name : 121413-001 10:1250

FileName : g:\gc15\cha\172A045.raw

Method : TEH\_CHA.ins

Start Time : 0.00 min

End Time : 31.92 min

File Factor: -1

Plot Offset: 33 mV

Sample #: 21307

Page 1 of 1

Date : 6/23/95 3:25 AM

Time of Injection: 6/23/95 2:51 AM

Low Point : 33.30 mV

High Point : 83.30 mV

Plot Scale: 50 mV

Response [mV]

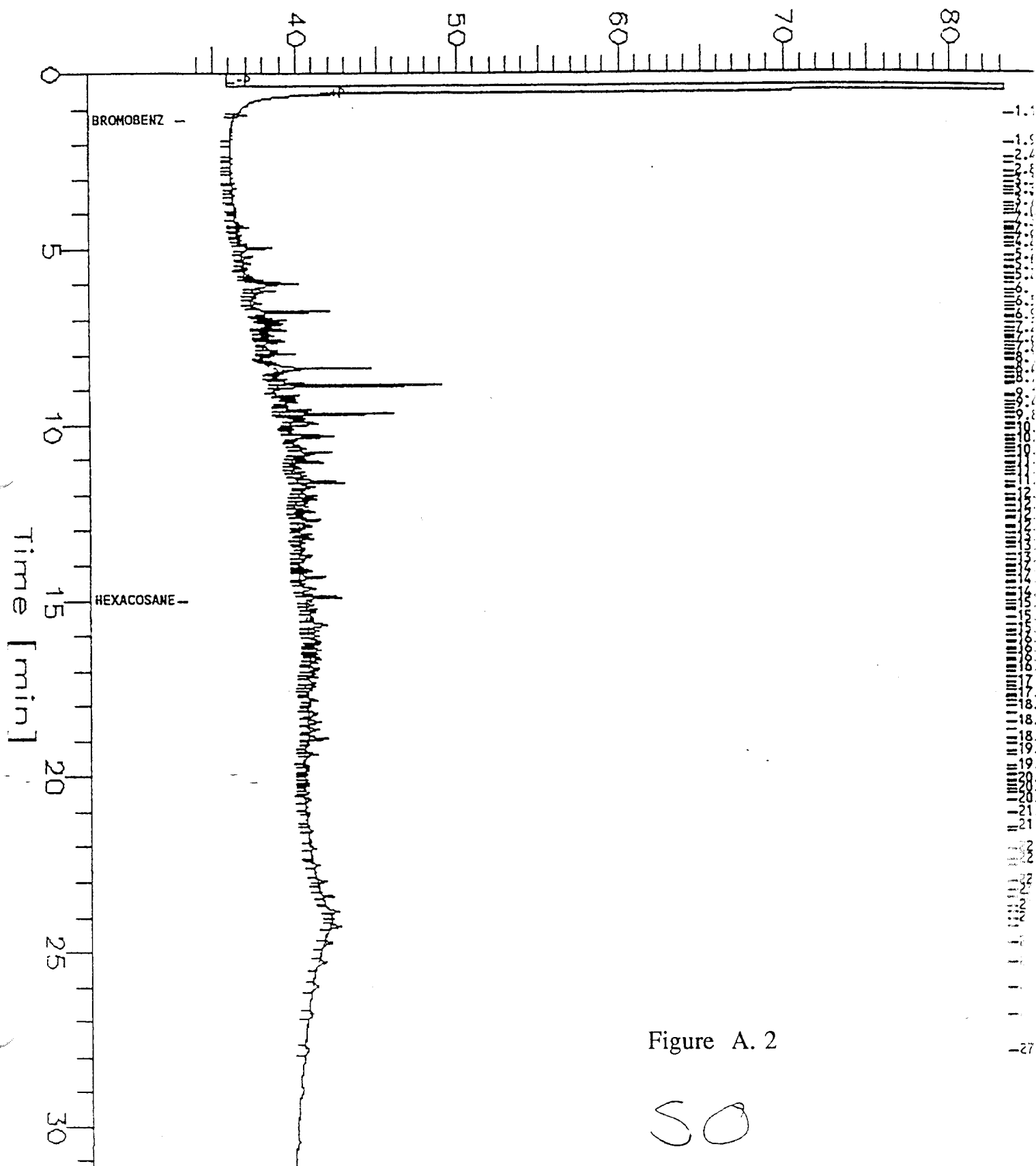


Figure A. 2

SO

Data File: /chem/bna02.1/061995X.b/05\_1413-1DL5.d  
 Date : 19-JUN-1995 10:39  
 Client ID: CURTIS & TOMPKINS, LTD  
 Sample Info:  
 Volume Injected (uL): 2.0  
 Column phase: Xt1 5 x .5 u

Instrument: bna02.1

Operator: Jon

Column diameter: 0.25

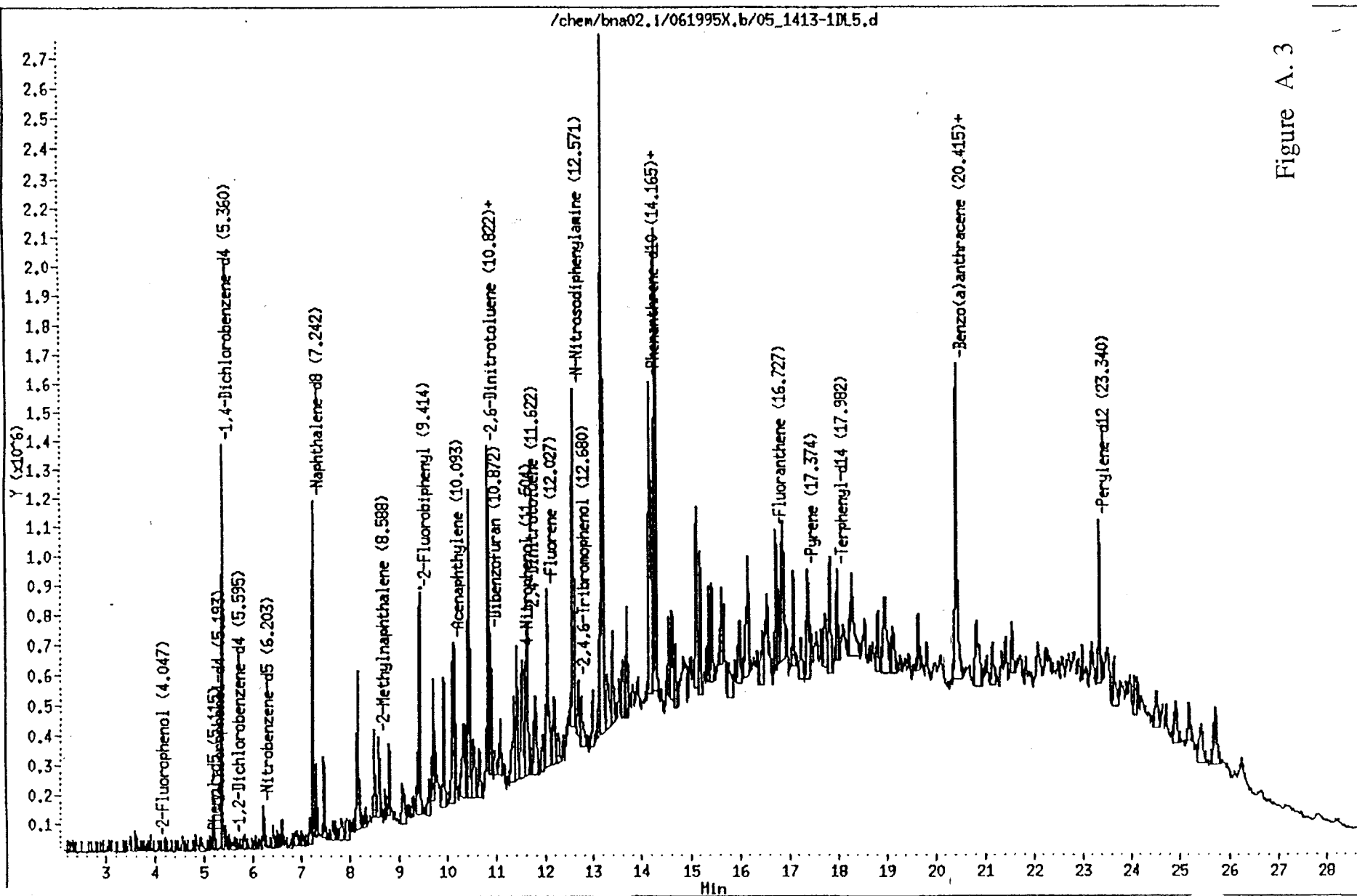


Figure A.3

## TEH Chromatogram GC11 CH A

Sample Name : c12-c60 mix

Sample #:

Page 1 of 1

eName : g:\gc11\cha\271A003A.raw

Date : 9/28/94 06:46 PM

Method : GC11DUAL.ins

Time of Injection: 9/28/94 06:14 PM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 25.28 mV

High Point : 75.28 mV

Scale Factor: -1

Plot Offset: 25 mV

Plot Scale: 50 mV

Response [mV]

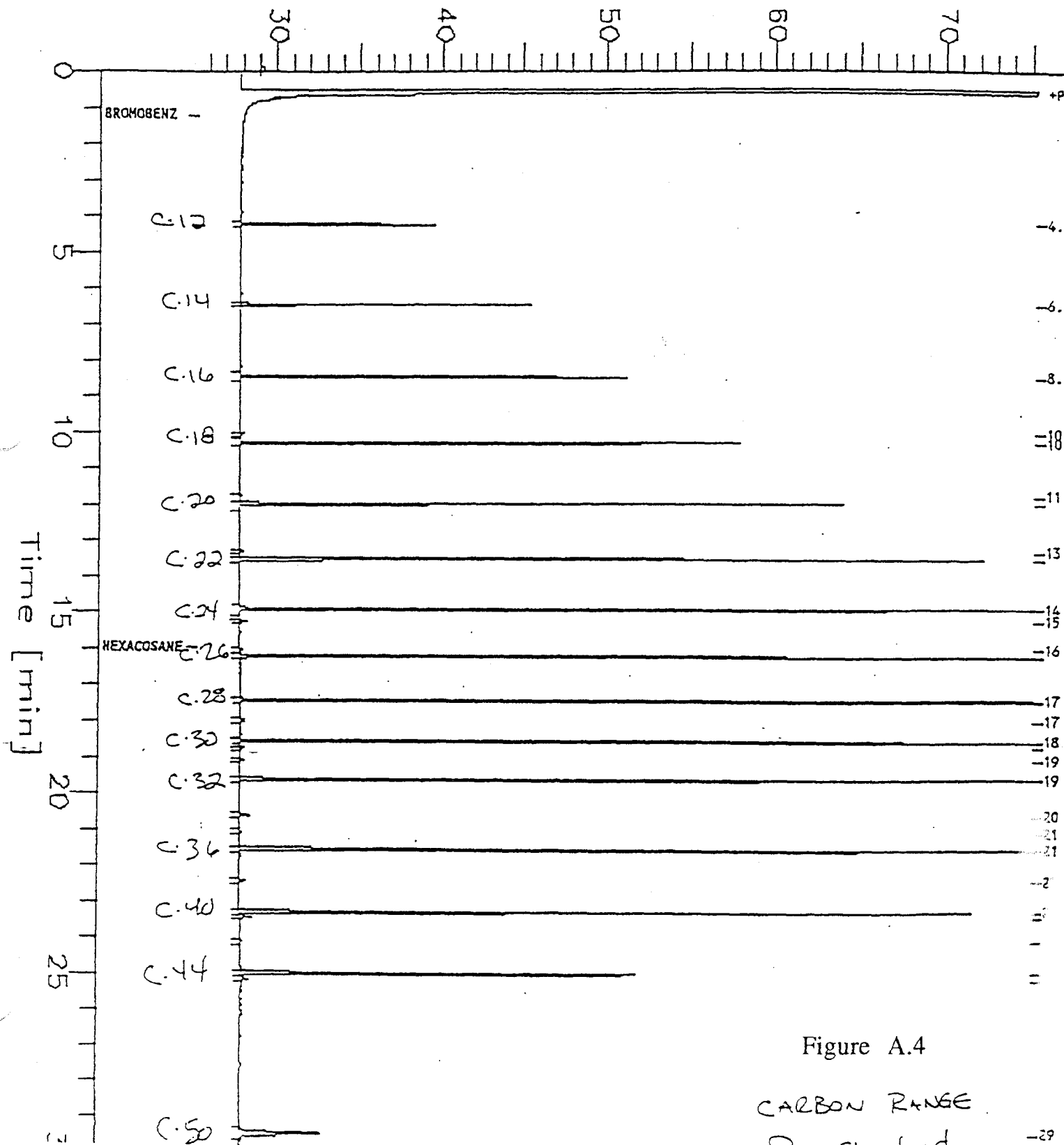


Figure A.4

CARBON RANGE

D<sub>1</sub> standard

Sample Name : Motor oil 1140 mg/L

Sample #: 94ws6545

Page 1 of 1

File Name : G:\GC11\CHA\015a004.raw

Date : 1/27/94 02:40 PM

Method : GC11DUAL.ins

Time of Injection: 1/15/94 05:16 PM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 29.90 mV

High Point : 79.90 mV

Scale Factor: -1

Plot Offset: 30 mV

Plot Scale: 50 mV

Response [mV]

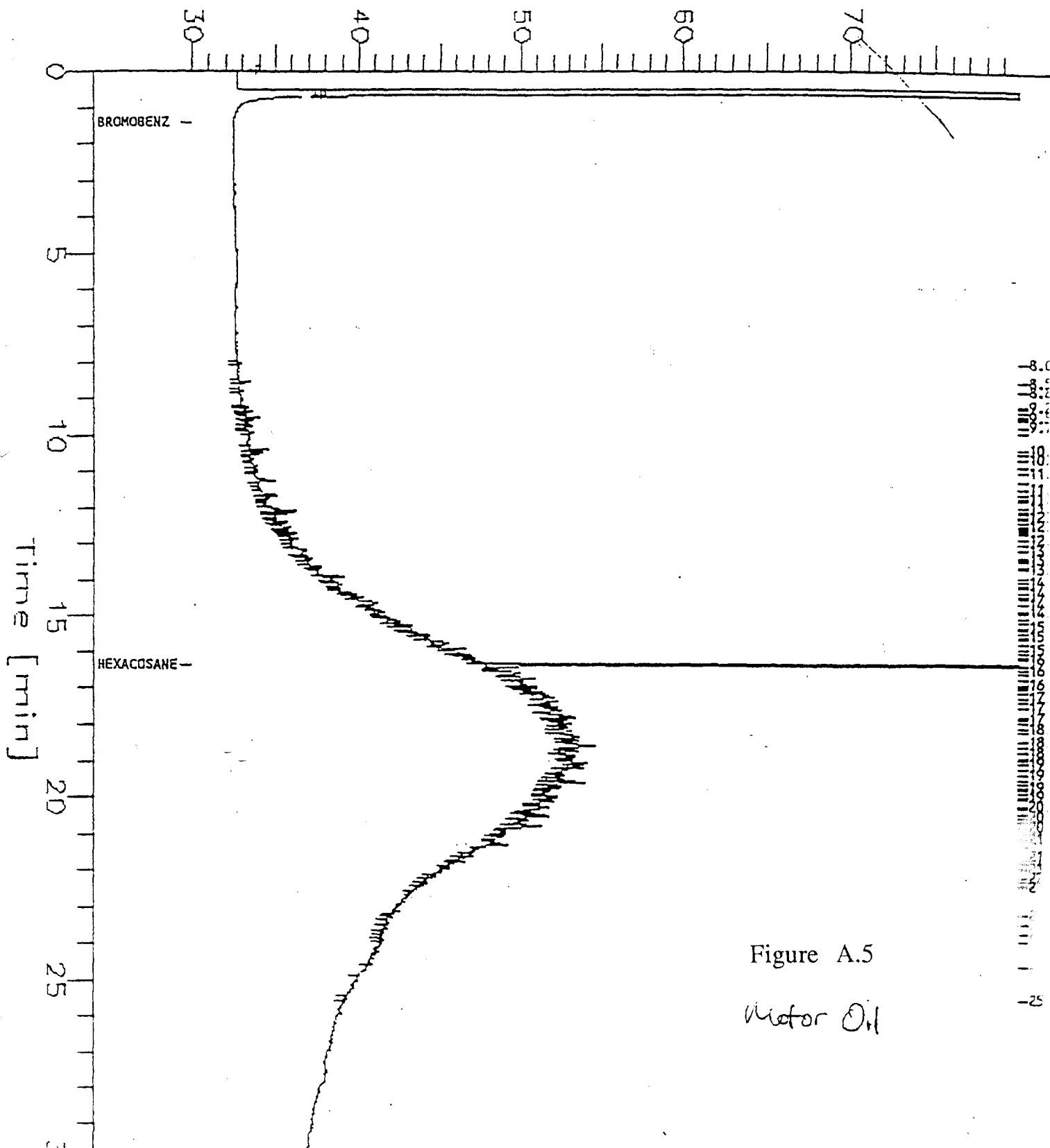


Figure A.5

Motor Oil

## TEH Chromatogram GC11 CH B

Sample Name : diesel 513mg/l

FileName : G:\GC11\CHB\2918003.raw

Method : GC11DUAL.ins

Start Time : 0.00 min

Scale Factor : -1

End Time : 31.92 min

Plot Offset: 34 mV

Sample #: 94ws8368

Date : 10/28/94 12:02 PM

Time of Injection: 10/18/94 01:30 PM

Low Point : 33.72 mV

Plot Scale: 50 mV

Page 1 of 1

High Point : 83.72 mV

Response [mV]

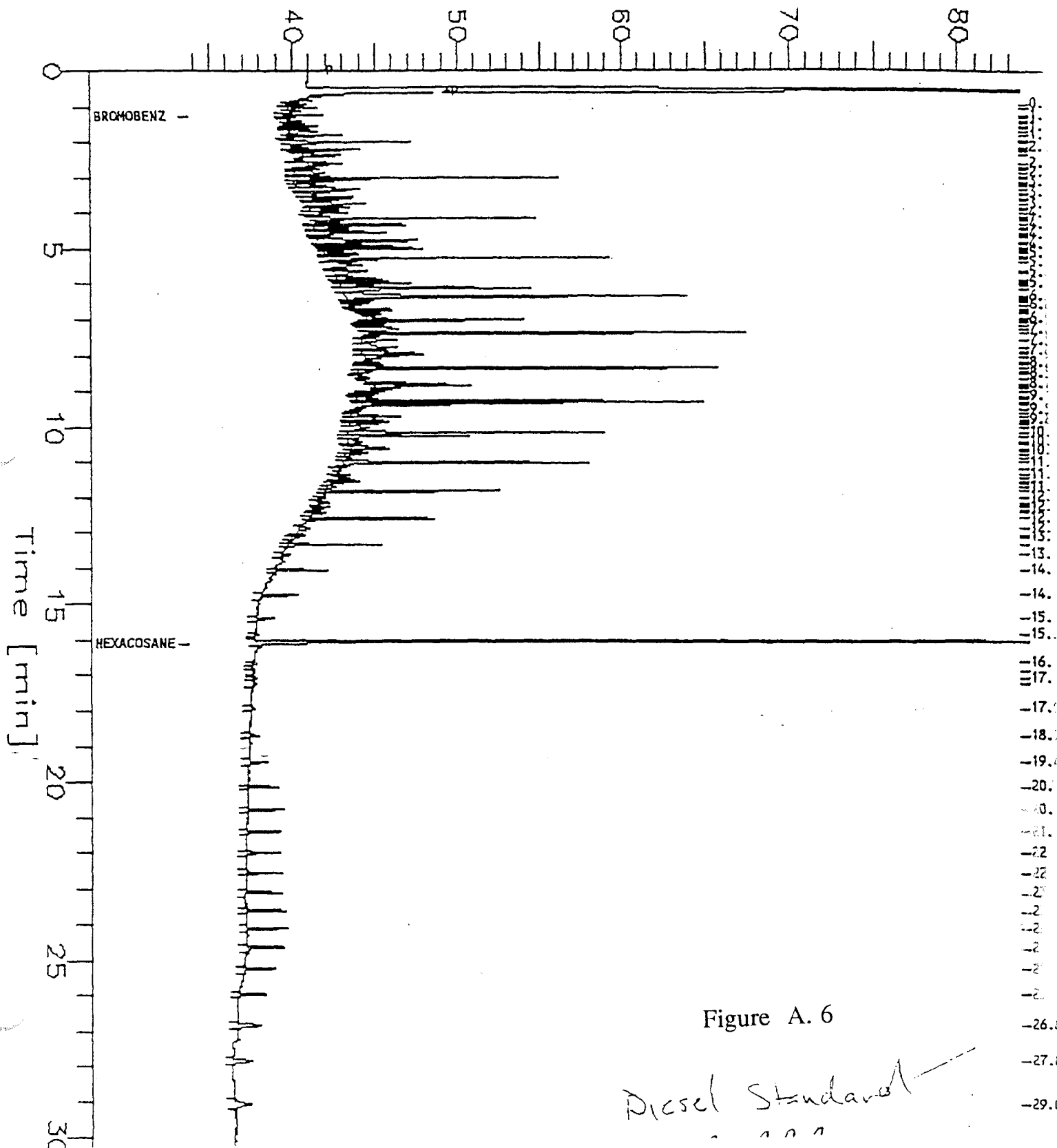


Figure A. 6

Diesel Standard

Sample Name : 121413-002 4.7:300  
 FileName : g:\gc15\cha\174A010.raw  
 Method : TEH\_CHA.ins  
 Start Time : 0.00 min  
 Scale Factor: -1

Sample #: 21307  
 Date : 6/23/95 7:57 PM  
 Time of Injection: 6/23/95 7:24 PM  
 End Time : 31.92 min  
 Plot Offset: 30 mV

Page 1 of 1  
 Low Point : 30.08 mV  
 High Point : 80.08 mV  
 Plot Scale: 50 mV

Response [mV]

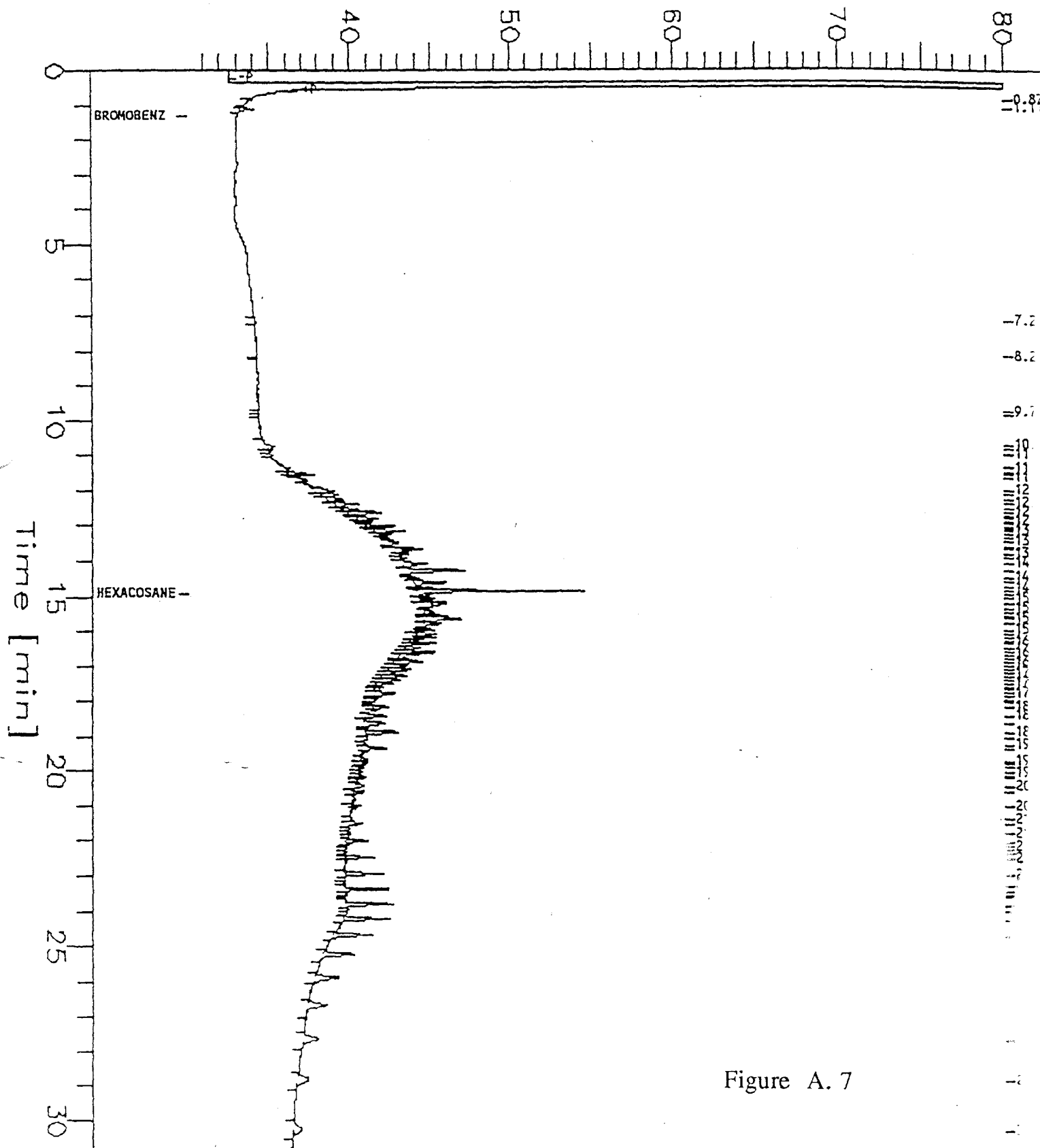


Figure A. 7

Sample Name : 121413-003 10:400

FileName : g:\gc15\cha\174A013.raw

Method : TEH\_CHA.ins

Start Time : 0.00 min

Scale Factor: -1

End Time : 31.92 min

Plot Offset: 29 mV

Sample #: 21307

Date : 6/23/95 10:06 PM

Time of Injection: 6/23/95 9:33 PM

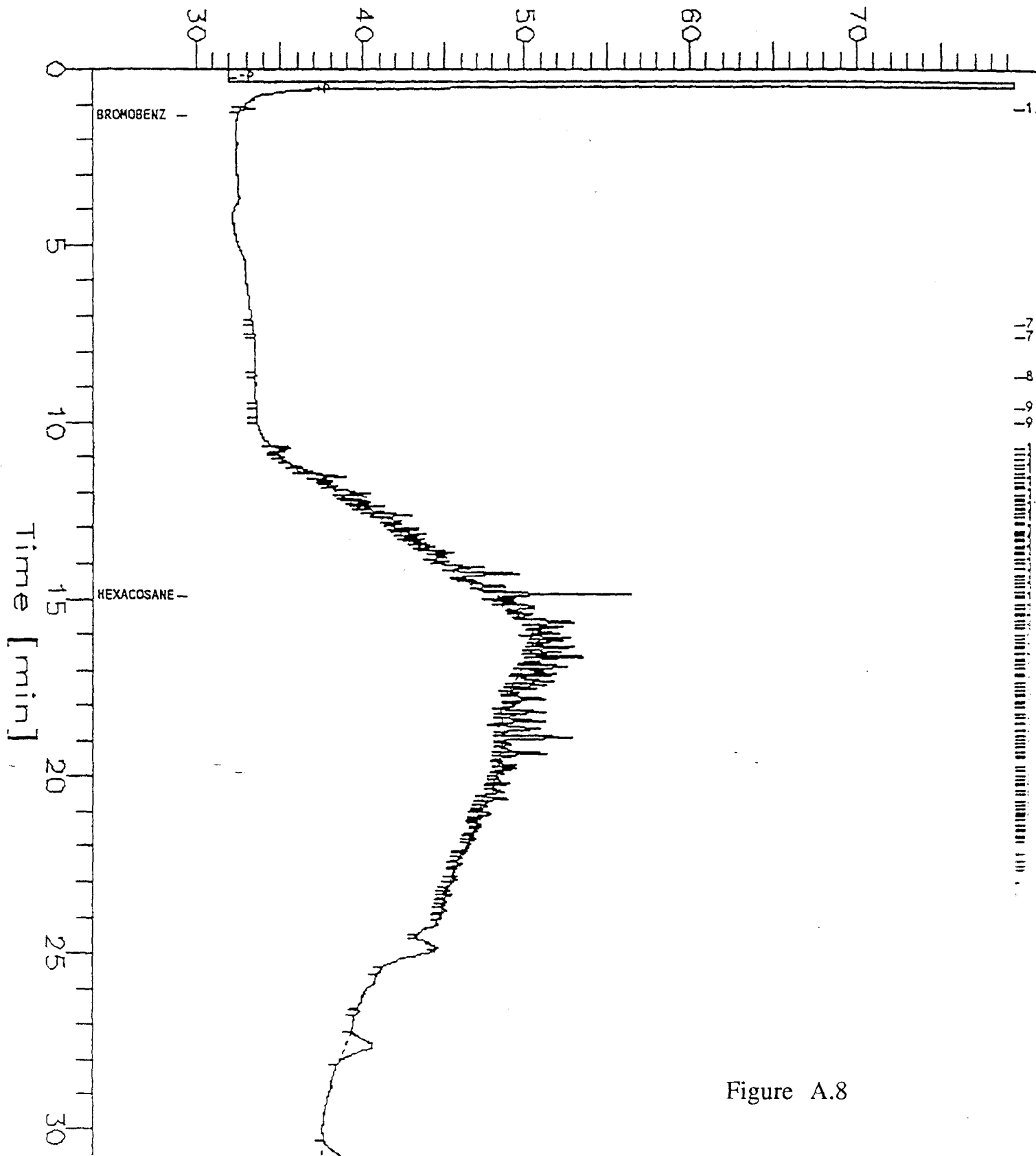
Low Point : 29.42 mV

Plot Scale: 50 mV

Page 1 of 1

High Point : 79.42 mV

Response [mV]





Sample Name : 121413-004 10:350

Sample #: 21307

Page 1 of 1

FileName : g:\gc15\cha\174A014.raw

Date : 6/23/95 10:49 PM

Method : TEH\_CHA.ins

Time of Injection: 6/23/95 10:16 PM

rt Time : 0.00 min

End Time : 31.92 min

Low Point : 30.32 mV

High Point : 80.32 mV

le Factor: -1

Plot Offset: 30 mV

Plot Scale: 50 mV

Response [mV]

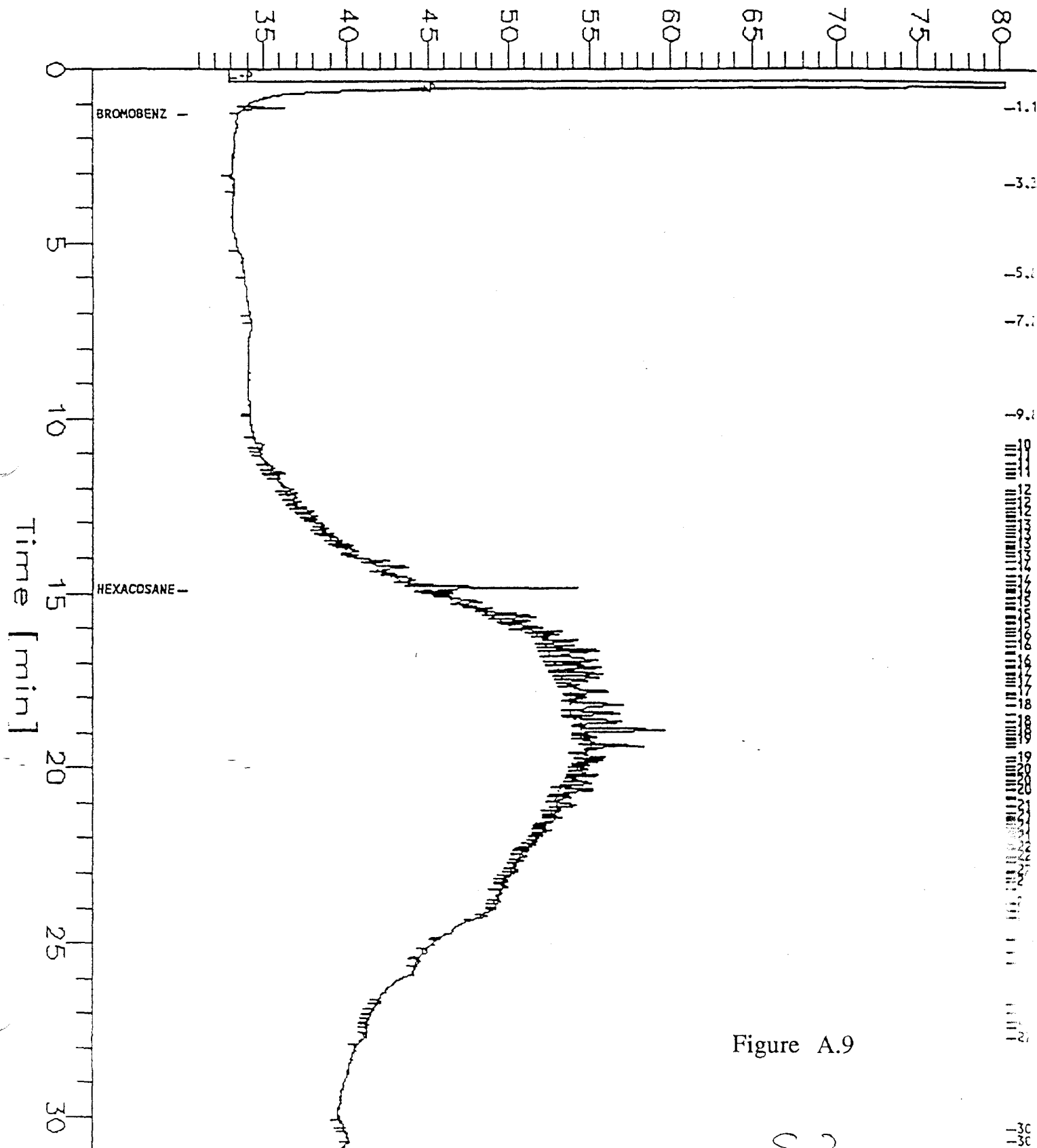


Figure A.9

Sample Name : 121413-005 10:300

FileName : g:\gc15\cha\174A015.raw

Method : TEH\_CHA.ins

Start Time : 0.00 min

End Time : 31.92 min

Scale Factor: -1

Plot Offset: 31 mV

Sample #: 21307

Date : 6/23/95 11:32 PM

Time of Injection: 6/23/95 10:59 PM

Low Point : 30.98 mV

Plot Scale: 50 mV

Page 1 of 1

High Point : 80.98 mV

Response [mV]

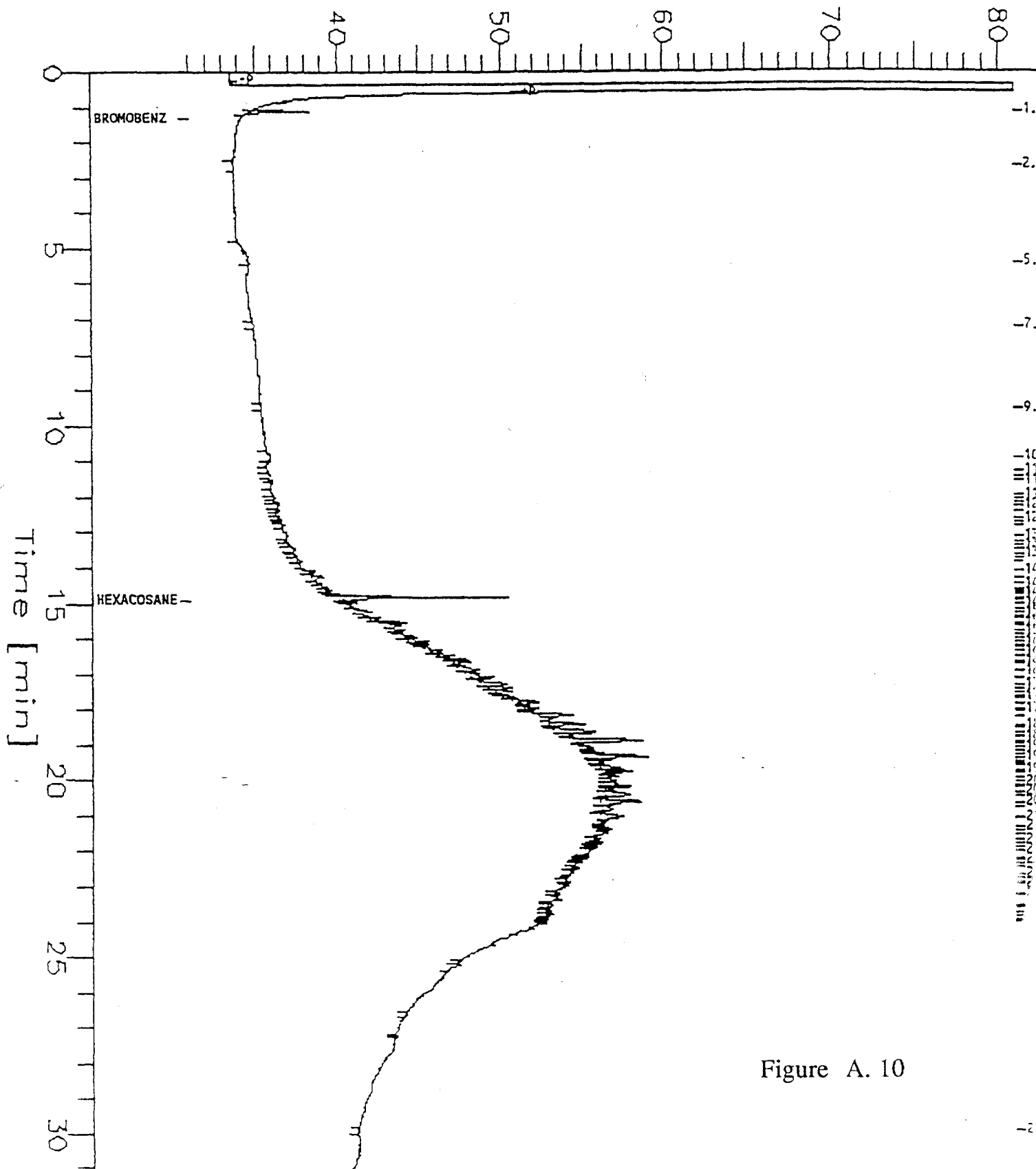


Figure A. 10

Sample Name : 121413-006 10:400  
FileName : g:\gc15\cha\177A028.raw  
Method : TEH\_CHA.ins  
Start Time : 0.00 min  
Scale Factor : -1

End Time : 31.92 min  
Plot Offset: 31 mV

Sample #: 21307  
Date : 6/28/95 02:48 PM  
Time of Injection: 6/27/95 02:48 PM  
Low Point : 31.36 mV  
Plot Scale: 50 mV  
High Point : 81.36 mV

Page 1 of 1

Response [mV]

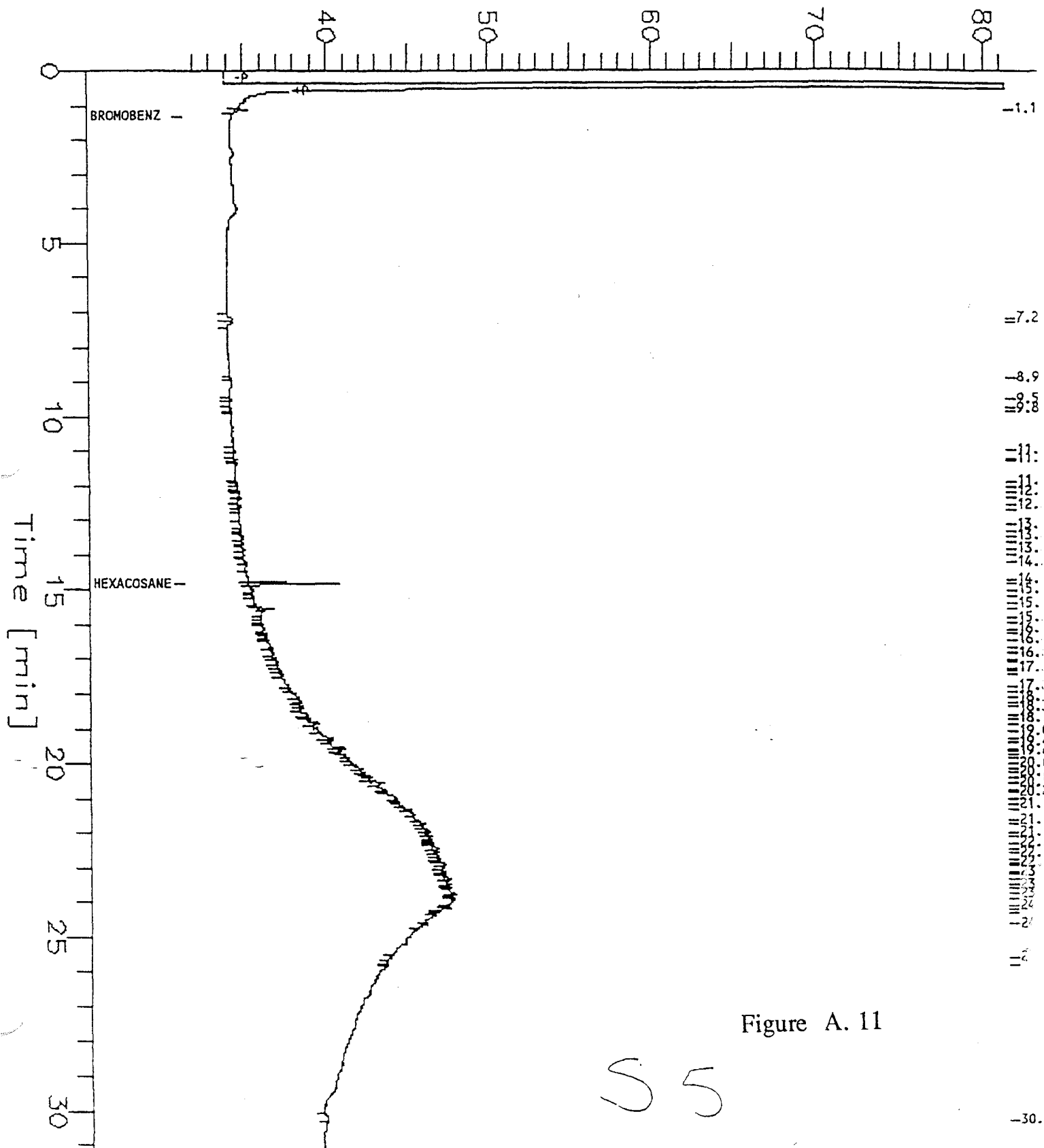


Figure A. 11

S 5

Sample Name : 121413-007 10:925

FileName : g:\gc15\cha\174A012.raw

Method : TEH\_CHA.ins

Time : 0.00 min

Factor: -1

End Time : 31.92 min

Plot Offset: 29 mV

Sample #: 21307

Date : 6/23/95 9:23 PM

Time of Injection: 6/23/95 8:50 PM

Low Point : 29.42 mV

Plot Scale: 50 mV

Page 1 of 1

Response [mV]

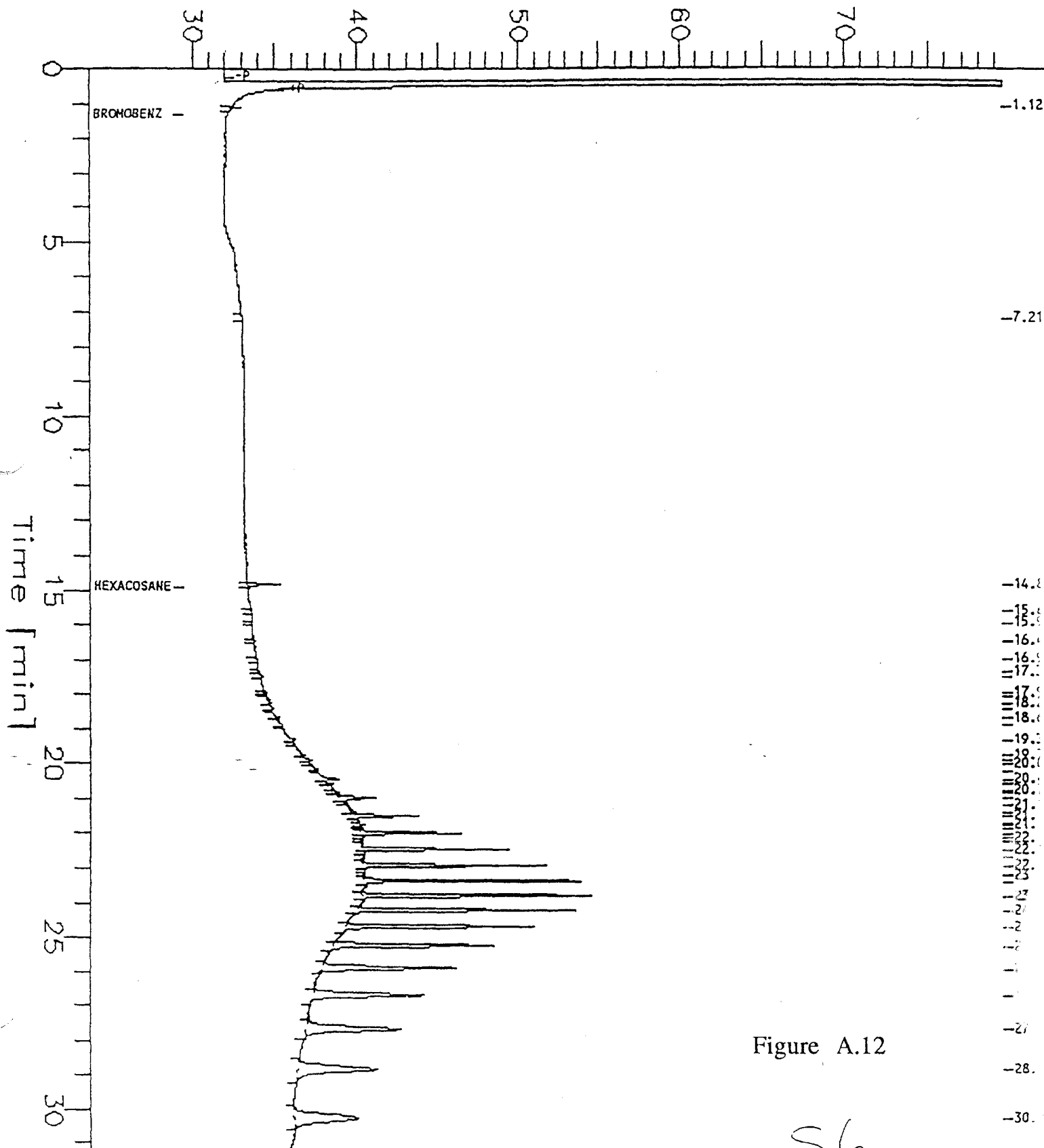


Figure A.12

56

Sample Name : 121413-008 10:925

Sample #: 21307

Page 1 of 1

FileName : g:\gc15\cha\174A011.raw

Date : 6/23/95 8:39 PM

Method : TEH\_CHA.ins

Time of Injection: 6/23/95 8:07 PM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 29.43 mV

High Point : 79.43 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

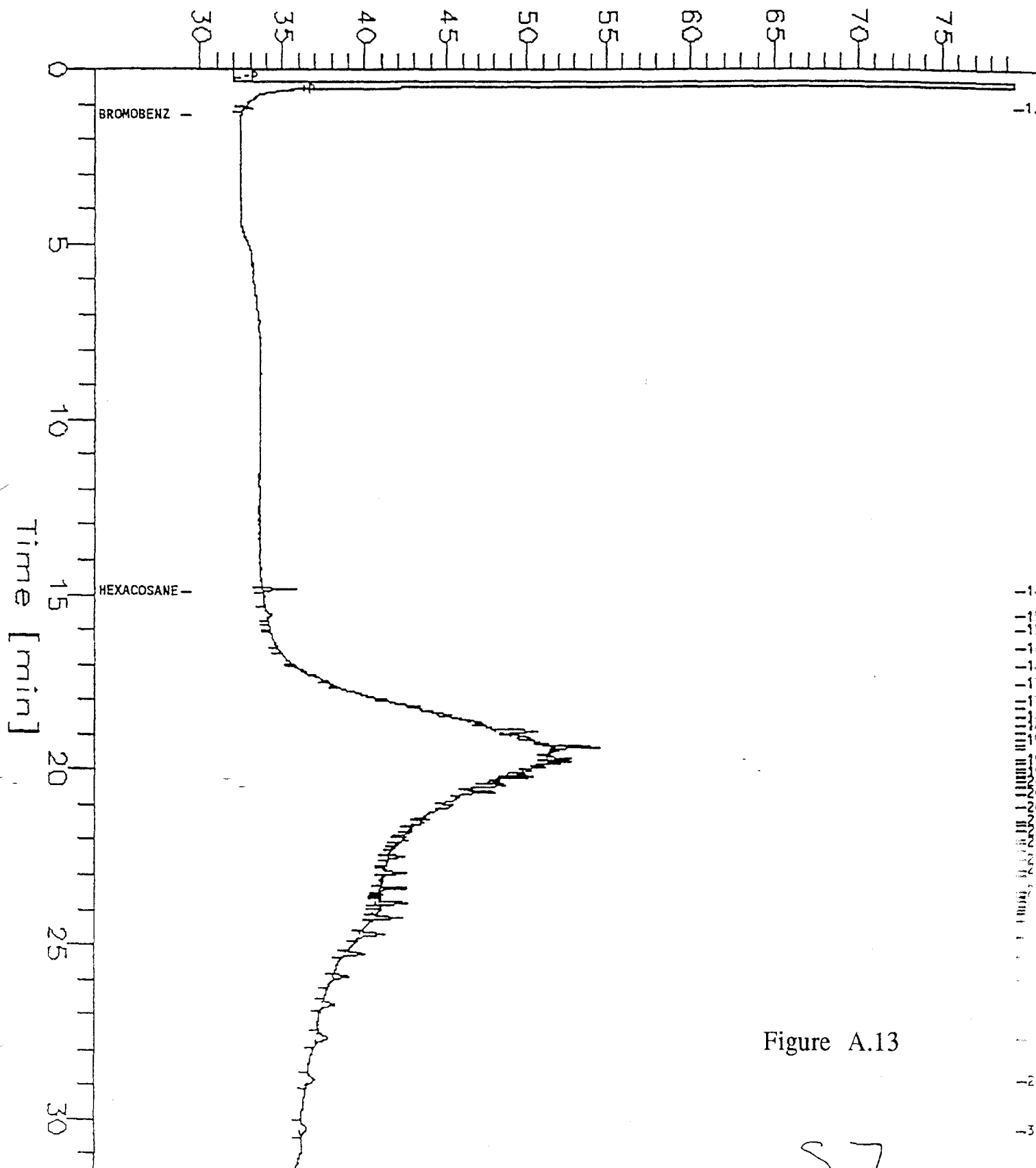


Figure A.13

S7

Sample Name : 121413-009 10:1900

Sample #: 21307

Page 1 of 1

FileName : g:\gc15\cha\172A047.raw

Date : 6/23/95 4:50 AM

Method : TEH\_CHA.ins

Time of Injection: 6/23/95 4:17 AM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 33.64 mV

High Point : 83.64 mV

Scale Factor: -1

Plot Offset: 34 mV

Plot Scale: 50 mV

Response [mV]

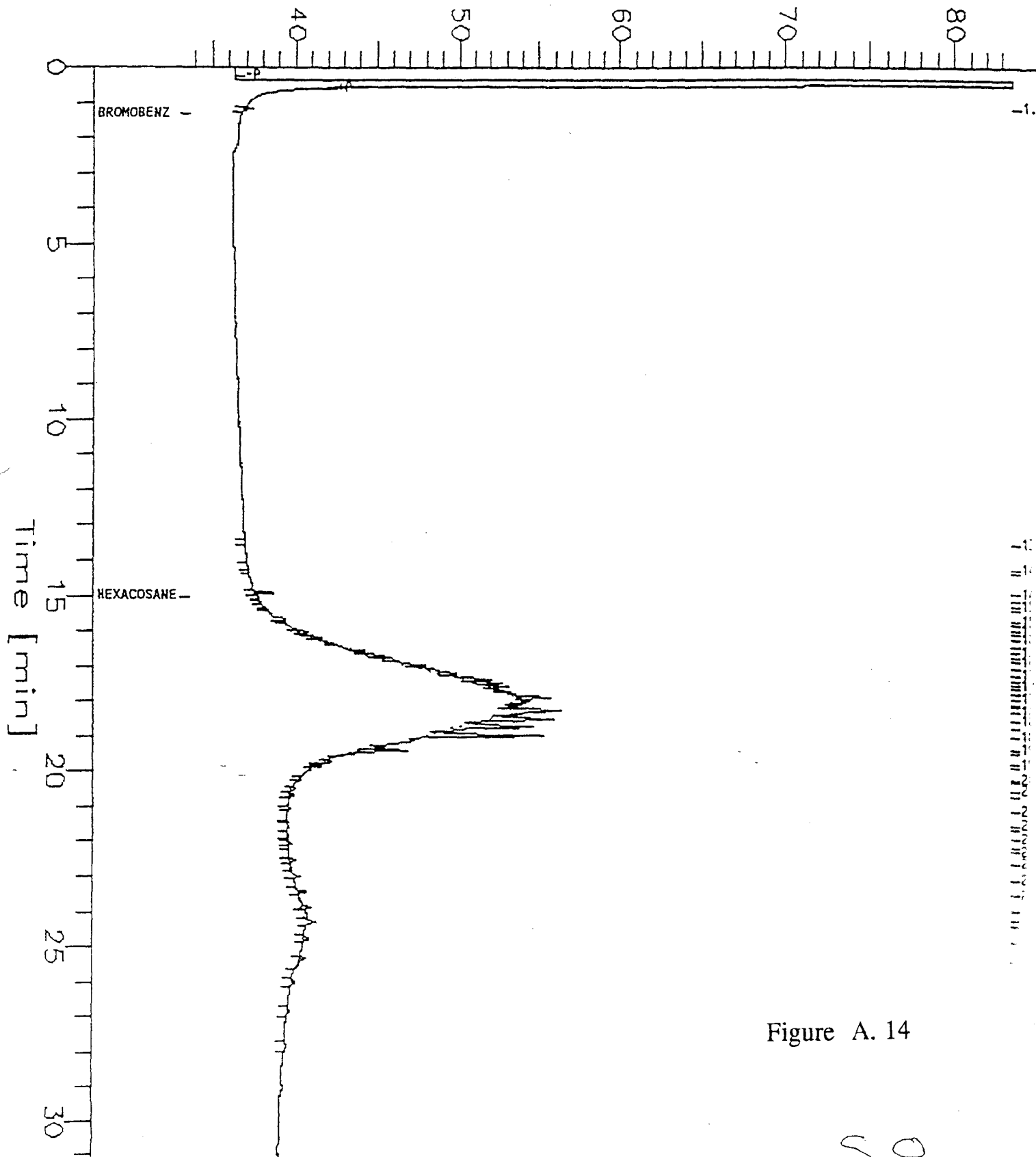


Figure A. 14

50

Sample Name : 121413-010 10:875

FileName : g:\gc15\cha\172A044.raw

Method : TEH\_CHA.ins

Start Time : 0.00 min

Scale Factor : -1

End Time : 31.92 min

Plot Offset: 32 mV

Sample #: 21307

Date : 6/23/95 2:40 AM

Time of Injection: 6/23/95 2:08 AM

Low Point : 32.17 mV

Plot Scale: 50 mV

Page 1 of 1

High Point : 82.17 mV

Response [mV]

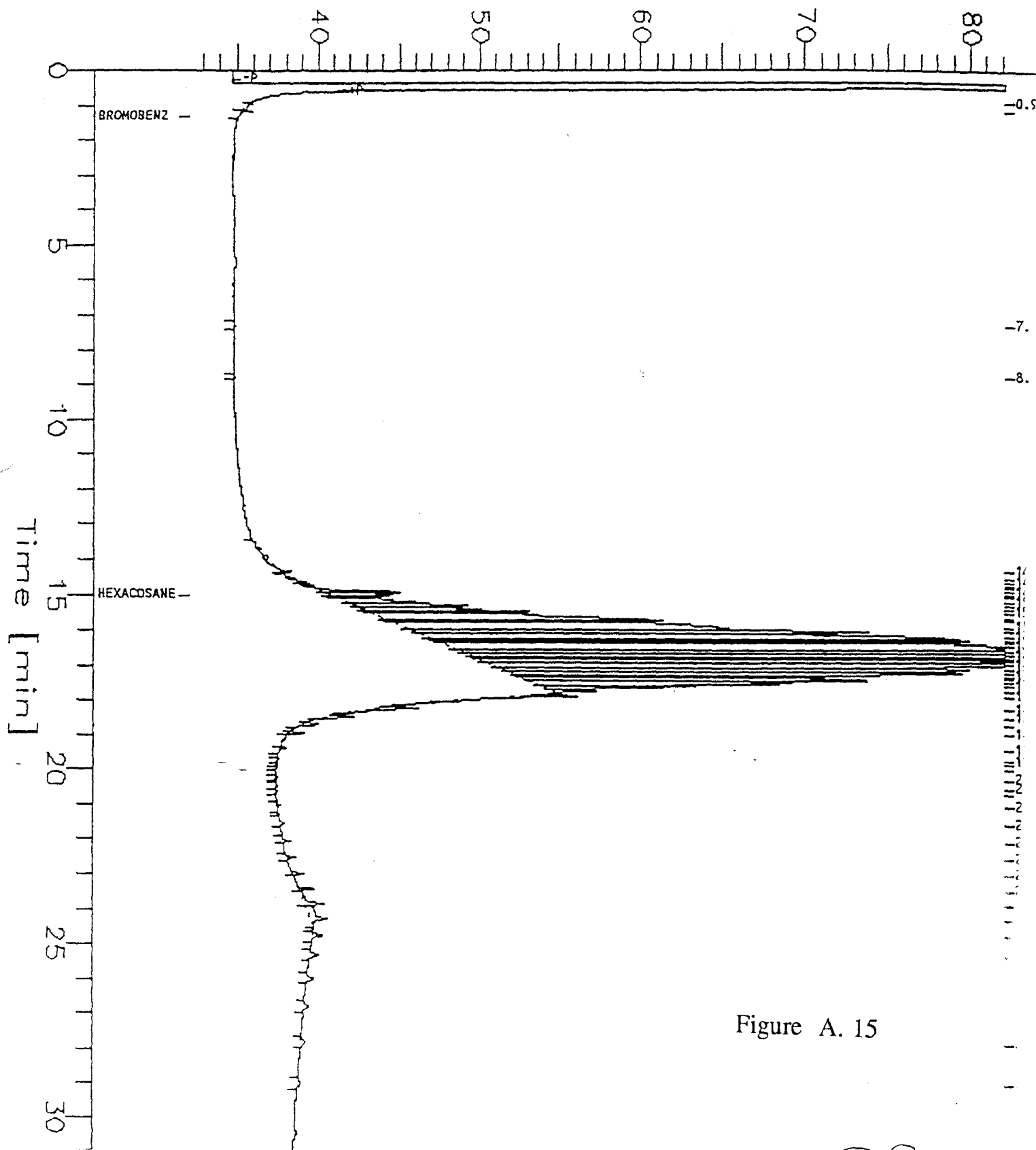
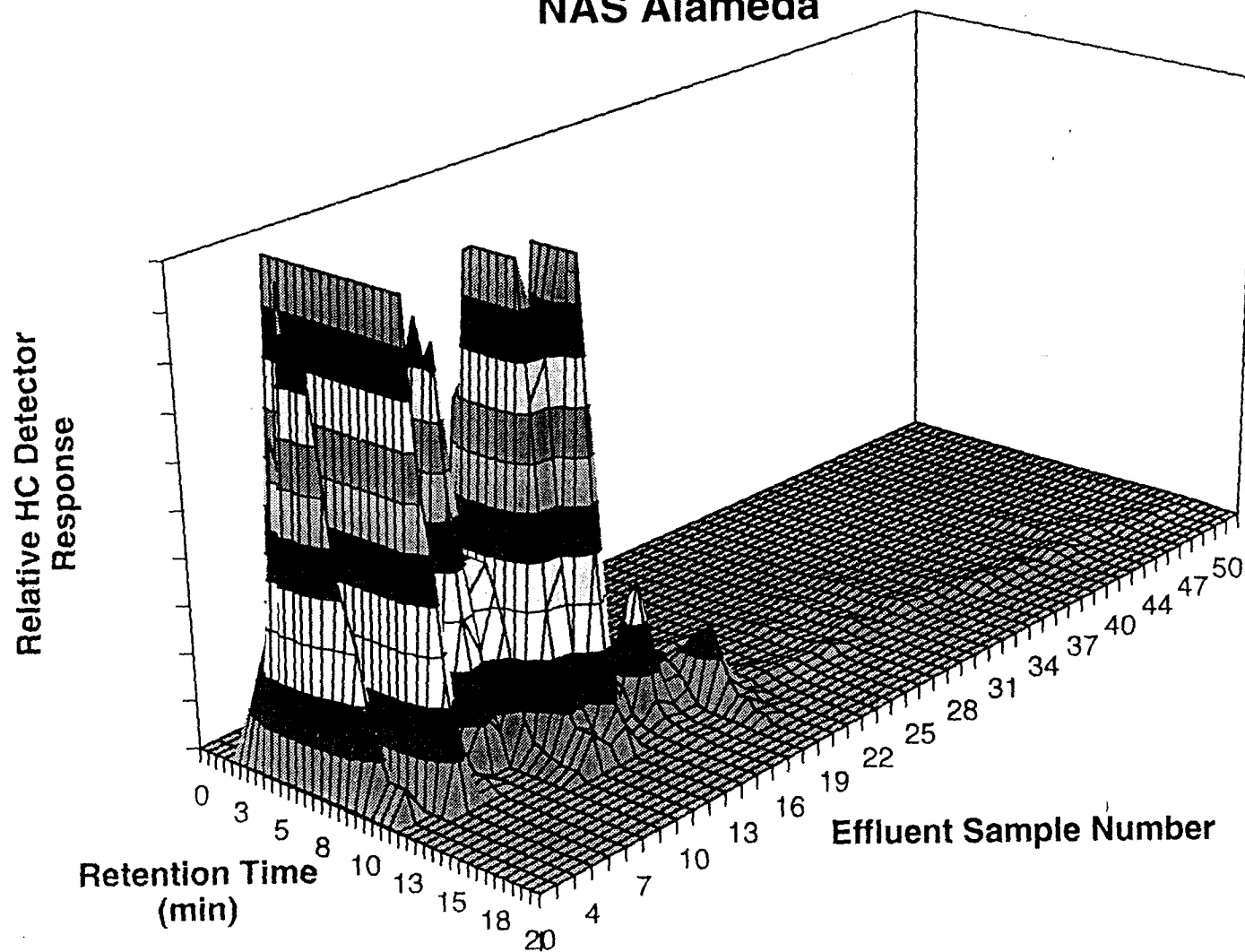


Figure A. 15

A 9

**Figure A.16. Effluent Liquid Chromatograms for the 1-Dimensional Steaming of Contaminated Soil from Site 13 -- NAS Alameda**





Diapor sk

## TEH Chromatogram GC15 CH A

Sample Name : 121433-001 38:2.5  
Sample Name : g:\gc15\cha\186a010.raw  
Method : TEH\_CHA.ins  
Start Time : 0.00 min  
Scale Factor : -1

End Time : 31.92 min  
Plot Offset: 45 mV

Sample #: 21532  
Date : 7/5/95 7:56 PM  
Time of Injection: 7/5/95 7:22 PM  
Low Point : 45.42 mV  
Plot Scale: 50 mV

Page 1 of 1

Response [mV]

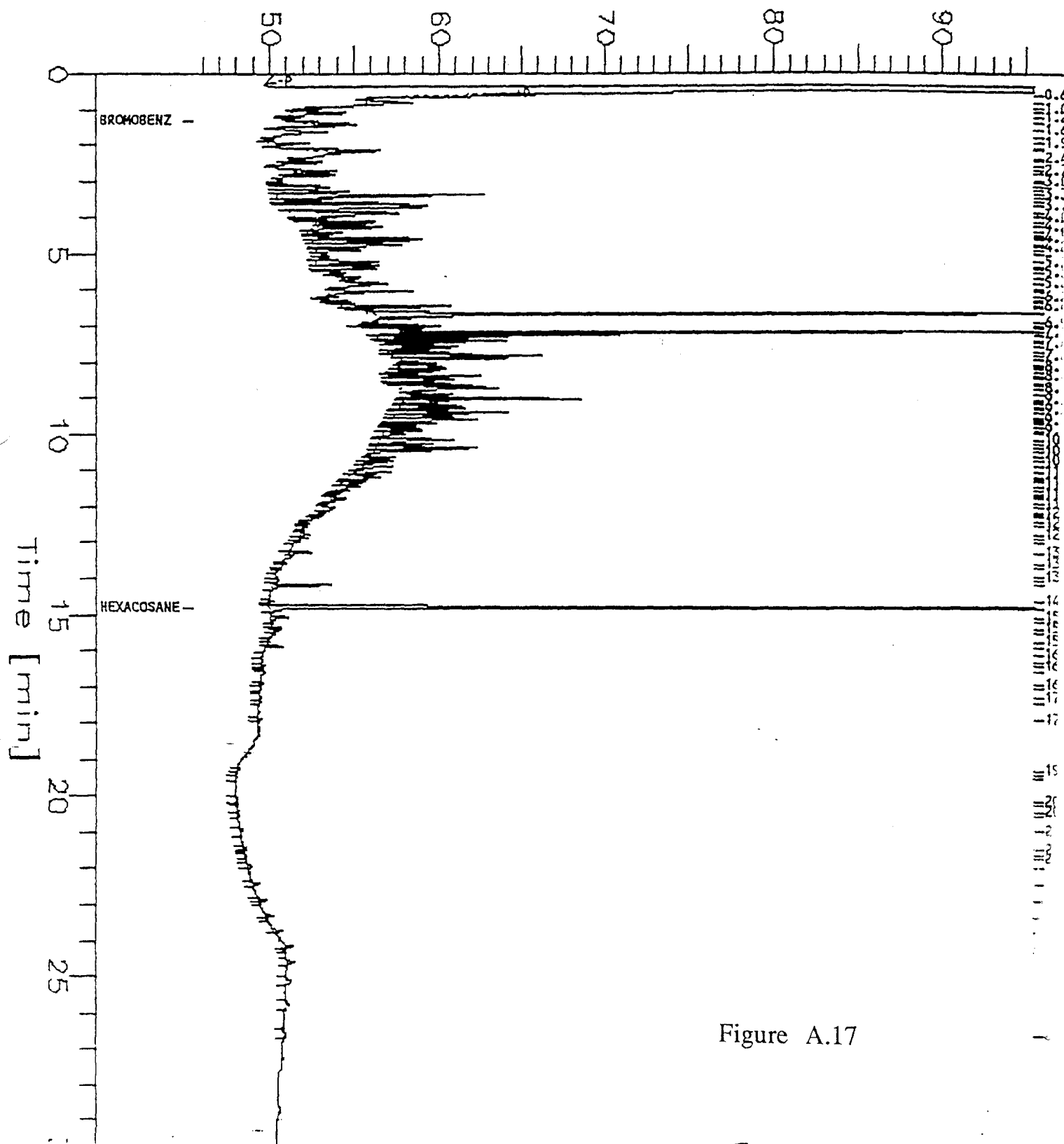


Figure A.17

JUL 17 '95 14:27 C&T

P.10

Kerosene STD

TEH Chromatogram GC11 CH A

Sample Name : 121433-002 51:250

Sample #: 21532

Page 1 of 1

File Name : g:\gc11\cha\188a039.raw

Date : 7/10/95 12:30 AM

Method : GC11DUAL.ins

Time of Injection: 7/9/95 11:57 PM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 28.47 mV

High Point : 78.47 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

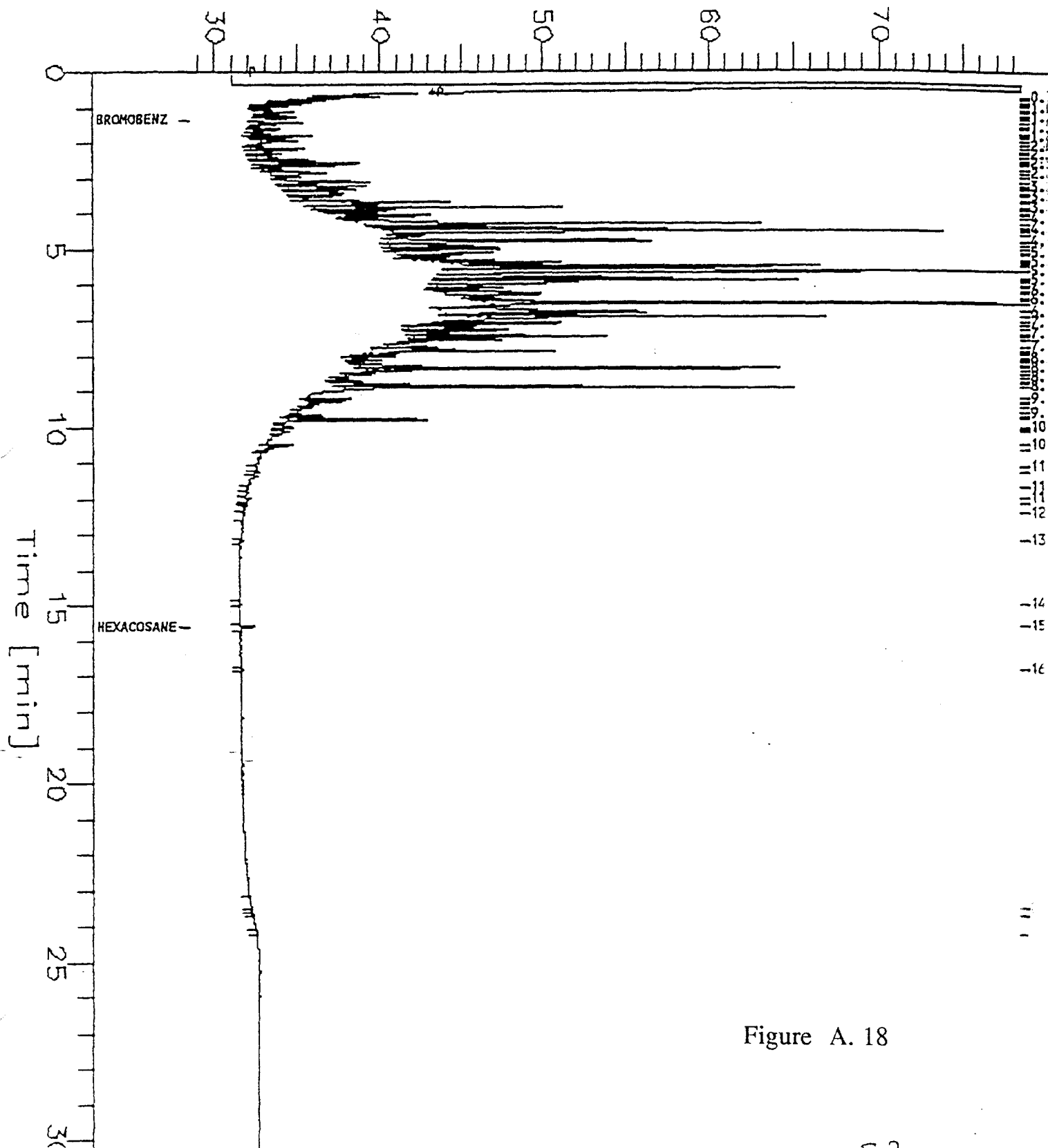


Figure A. 18

TEH Chromatogram GC15 CH A

File Name : 121433-003 38:2.5  
eName : G:\GC15\CHA\186a011.raw  
Method : TEH\_CHA.ins  
Start Time : 0.01 min  
Scale Factor: 0

End Time : 31.87 min  
Plot Offset: 27 mV

Sample #: 21532  
Date : 7/6/95 10:49 AM  
Time of Injection: 7/5/95 8:06 PM  
Low Point : 27.02 mV High Point : 278.43 mV  
Plot Scale: 251 mV

Page 1 of 1

Response [mV]

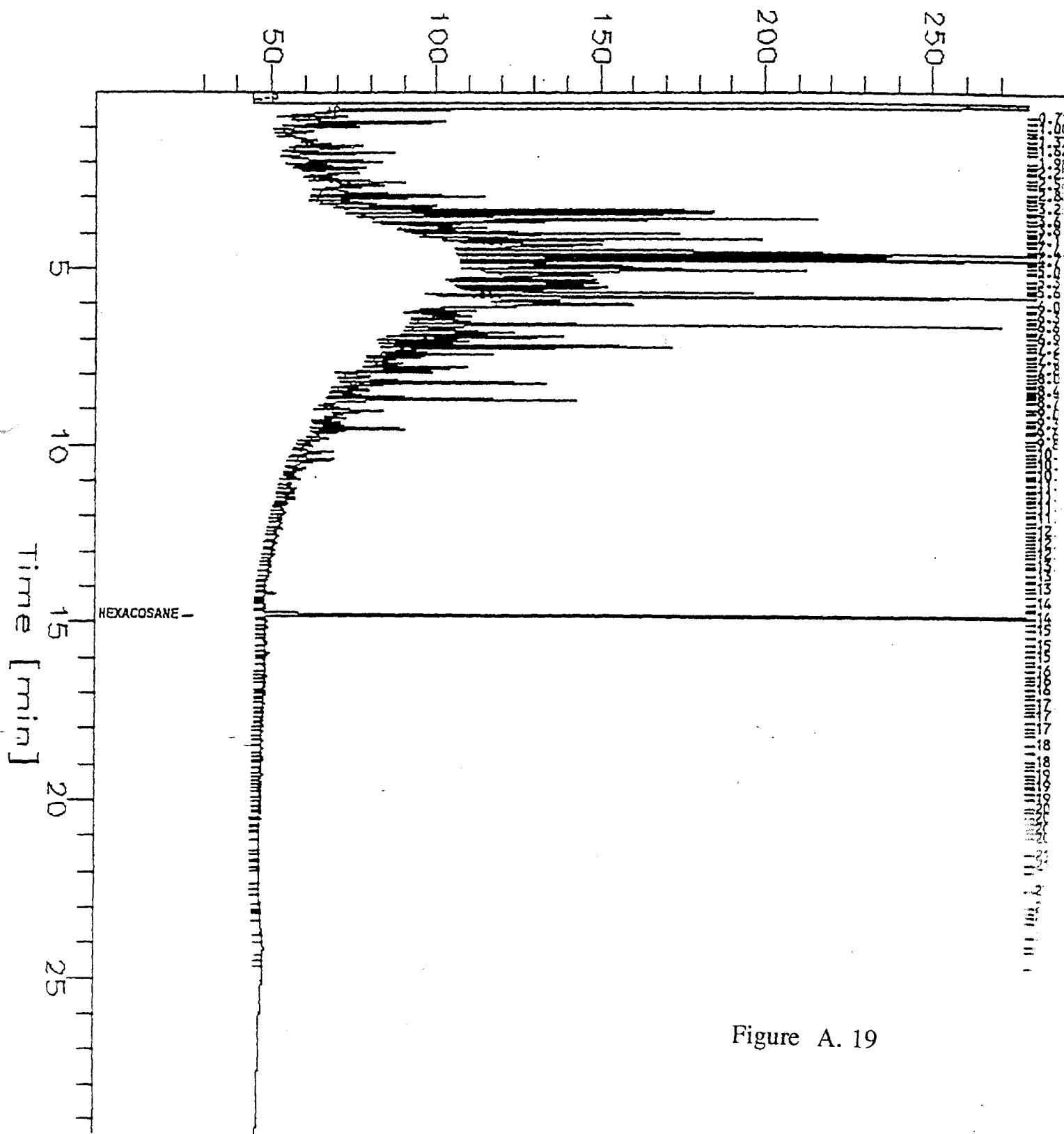


Figure A. 19

JUL 17 '95 14:28 C&T

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P.12

TEH Chromatogram GC11 CH A

Sample Name : 121433-004 41:500  
Sample Name : g:\gc11\cha\188a040.raw  
Method : GC11DUAL.ins  
Start Time : 0.00 min  
Scale Factor : -1  
End Time : 31.92 min  
Plot Offset : 29 mV

Sample #: 21532  
Date : 7/10/95 01:14 AM  
Time of Injection: 7/10/95 12:40 AM  
Low Point : 28.66 mV  
Plot Scale: 50 mV  
High Point : 78.66 mV

Page 1 of 1

Response [mV]

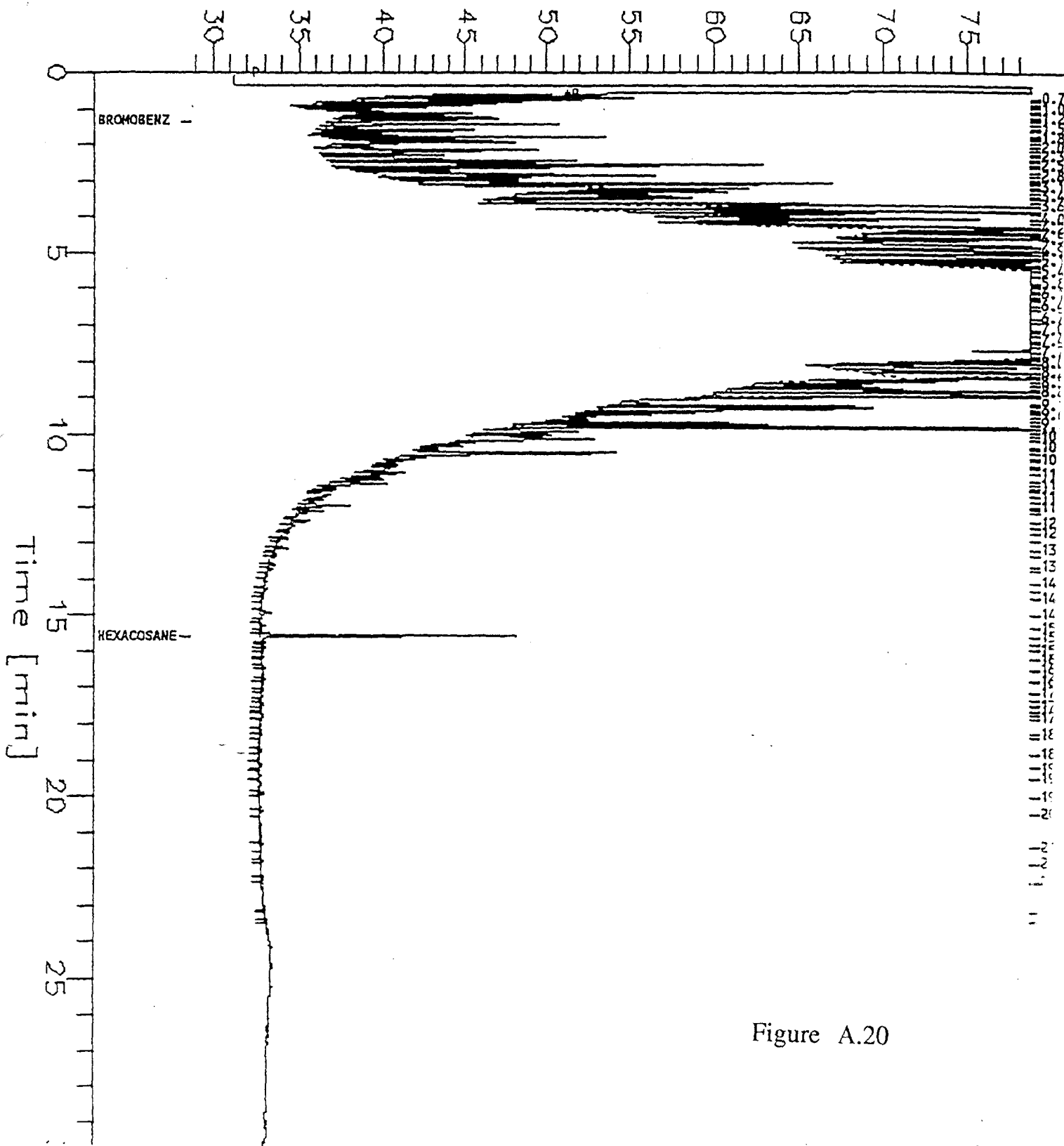


Figure A.20

Diesel 5/4

## TEH Chromatogram GC11 CH A

Sample Name : 121433-005 45:50  
FileName : g:\gc11\cha\188a041.raw  
Method : GC11DUAL.ins  
Start Time : 0.00 min End Time : 31.92 min  
Scale Factor : -1 Plot Offset: 29 mV

Sample #: 21532 Page 1 of 1  
Date : 7/10/95 01:57 AM  
Time of Injection: 7/10/95 01:24 AM  
Low Point : 29.13 mV High Point : 79.13 mV  
Plot Scale: 50 mV

Response [mV]

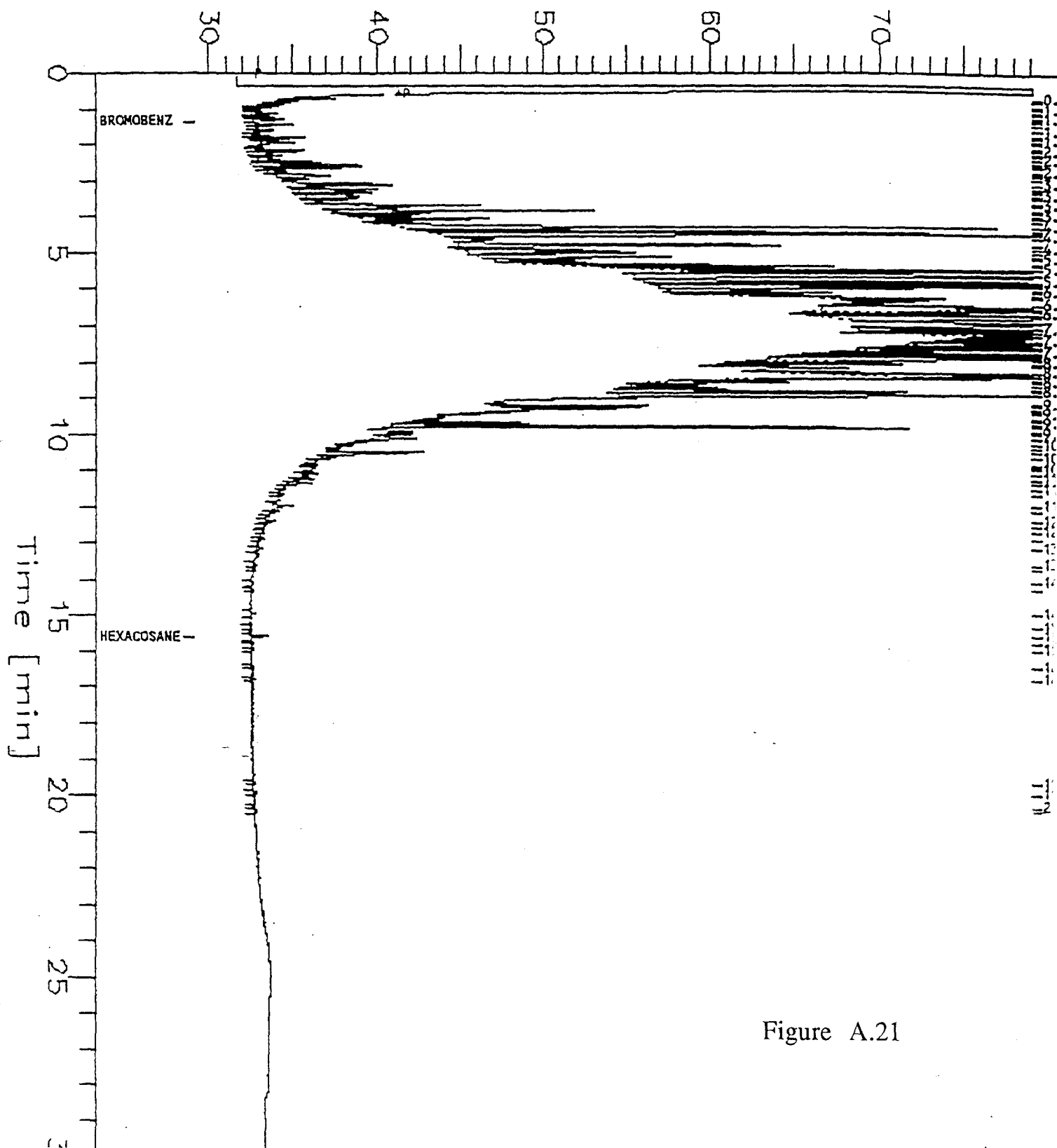


Figure A.21

JUL 18 '95 16:50  
Dose 578

TEH Chromatogram GC11 CH A

P.5

Sample Name : 121433-006,500:500

Sample #: 21532

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FileName : g:\gc11\cha\198a009.raw

Date : 7/18/95 01:36 AM

Method : GC11DUAL.ins

Time of Injection: 7/18/95 01:03 AM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 28.92 mV

High Point : 78.92 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

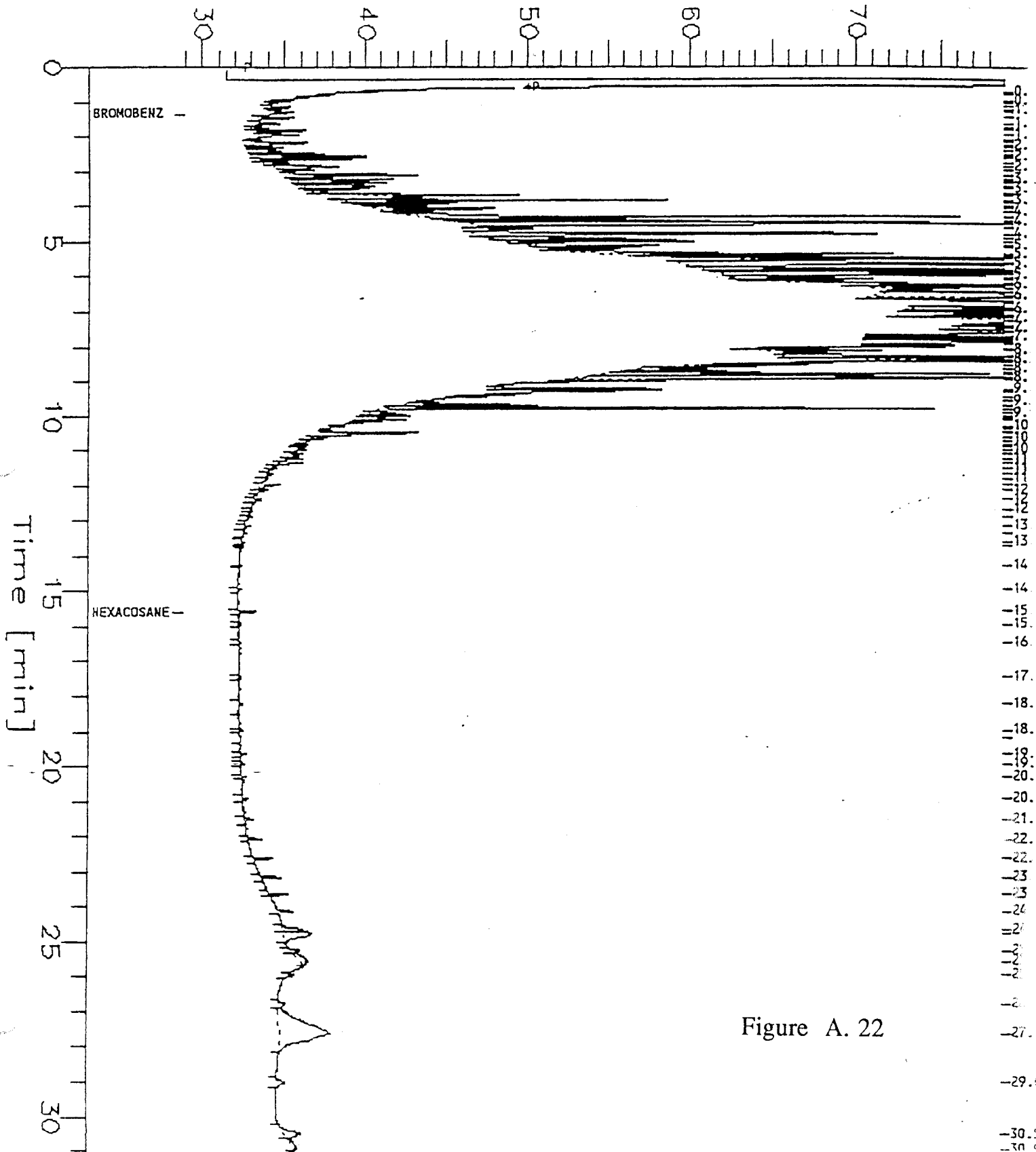


Figure A. 22

## TEH Chromatogram GC11 CH B

Sample Name : 121433-007 150:500  
FileName : g:\gc11\chb\188b006.raw  
Method : GC11DUAL.ins  
Start Time : 0.00 min End Time : 31.92 min  
Scale Factor: -1 Plot Offset: 28 mV

Sample #: 21532  
Date : 7/8/95 09:49 PM  
Time of Injection: 7/8/95 09:16 PM  
Low Point : 28.26 mV High Point : 78.26 mV  
Plot Scale: 50 mV

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Response [mV]

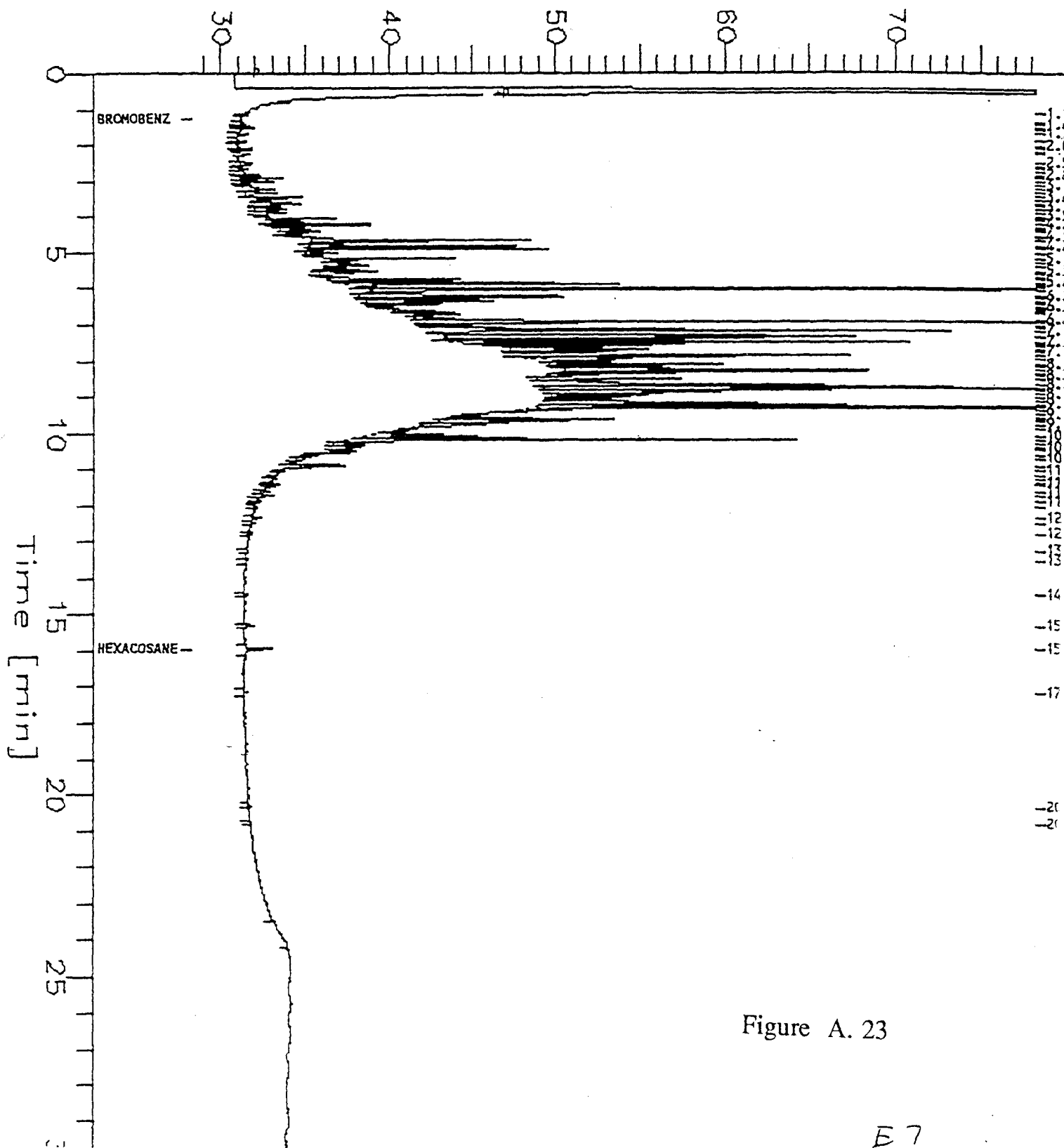


Figure A. 23

## TEH Chromatogram GC11 CH B

Sample Name : 121433-008 140:100  
FileName : g:\gc11\chb\188b007.raw  
Method : GC11DUAL.ins  
Start Time : 0.00 min  
Scale Factor: -1

End Time : 31.92 min  
Plot Offset: 28 mV

Sample #: 21532  
Date : 7/8/95 10:34 PM  
Time of Injection: 7/8/95 09:59 PM  
Low Point : 28.37 mV  
Plot Scale: 50 mV

Page 1 of 1

High Point : 78.37 mV

Response [mV]

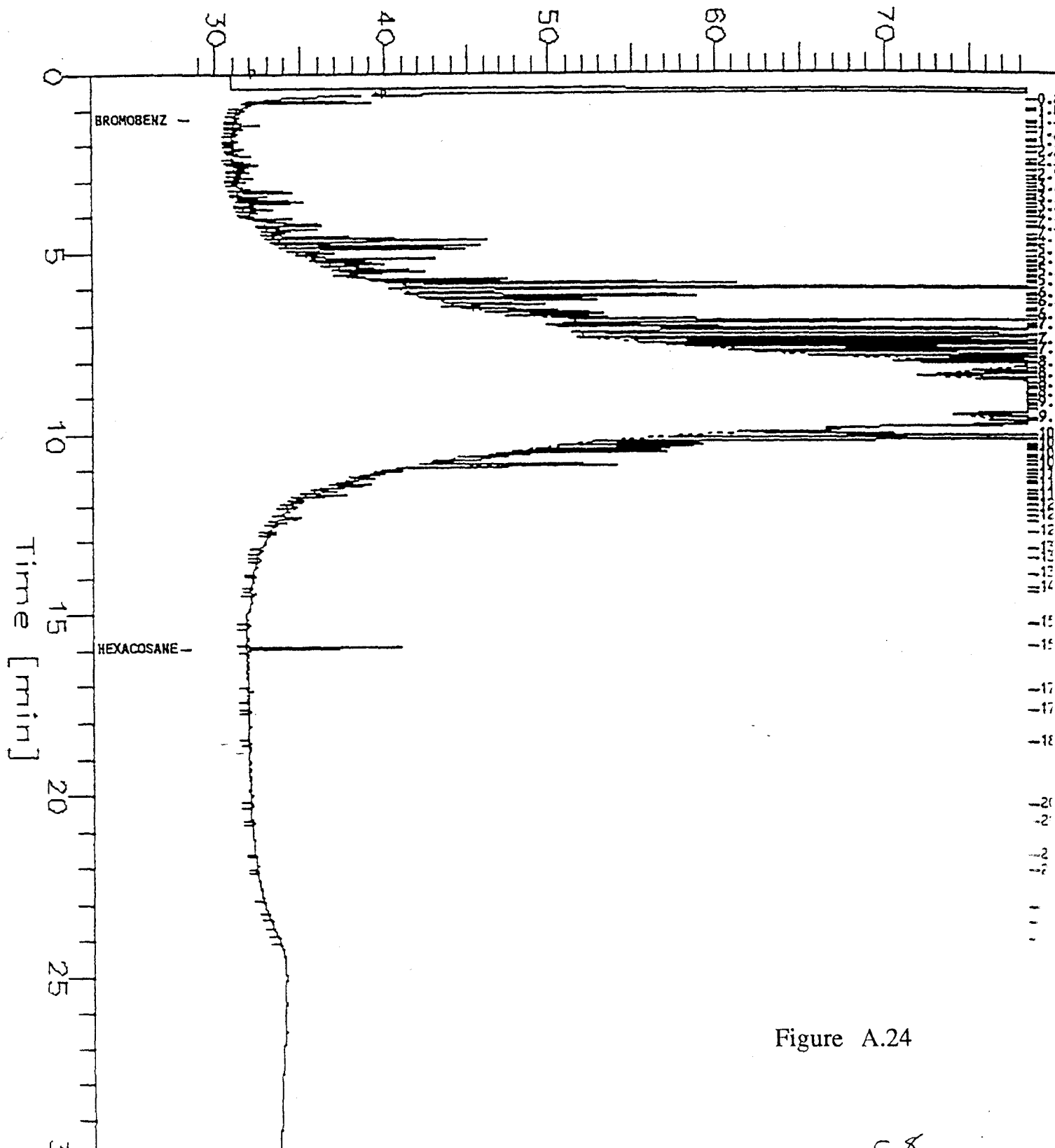


Figure A.24



## TEH Chromatogram GC11 CH B

Le Name : 121433-009 150:100  
Name : g:\gc11\chb\1886008.raw  
Method : GC11DUAL.ins  
Start Time : 0.00 min  
Scale Factor: -1

End Time : 31.92 min  
Plot Offset: 28 mV

Sample #: 21532  
Date : 7/8/95 11:18 PM  
Time of Injection: 7/8/95 10:43 PM  
Low Point : 28.38 mV  
Plot Scale: 50 mV

Page 1 of 1

Response [mV]

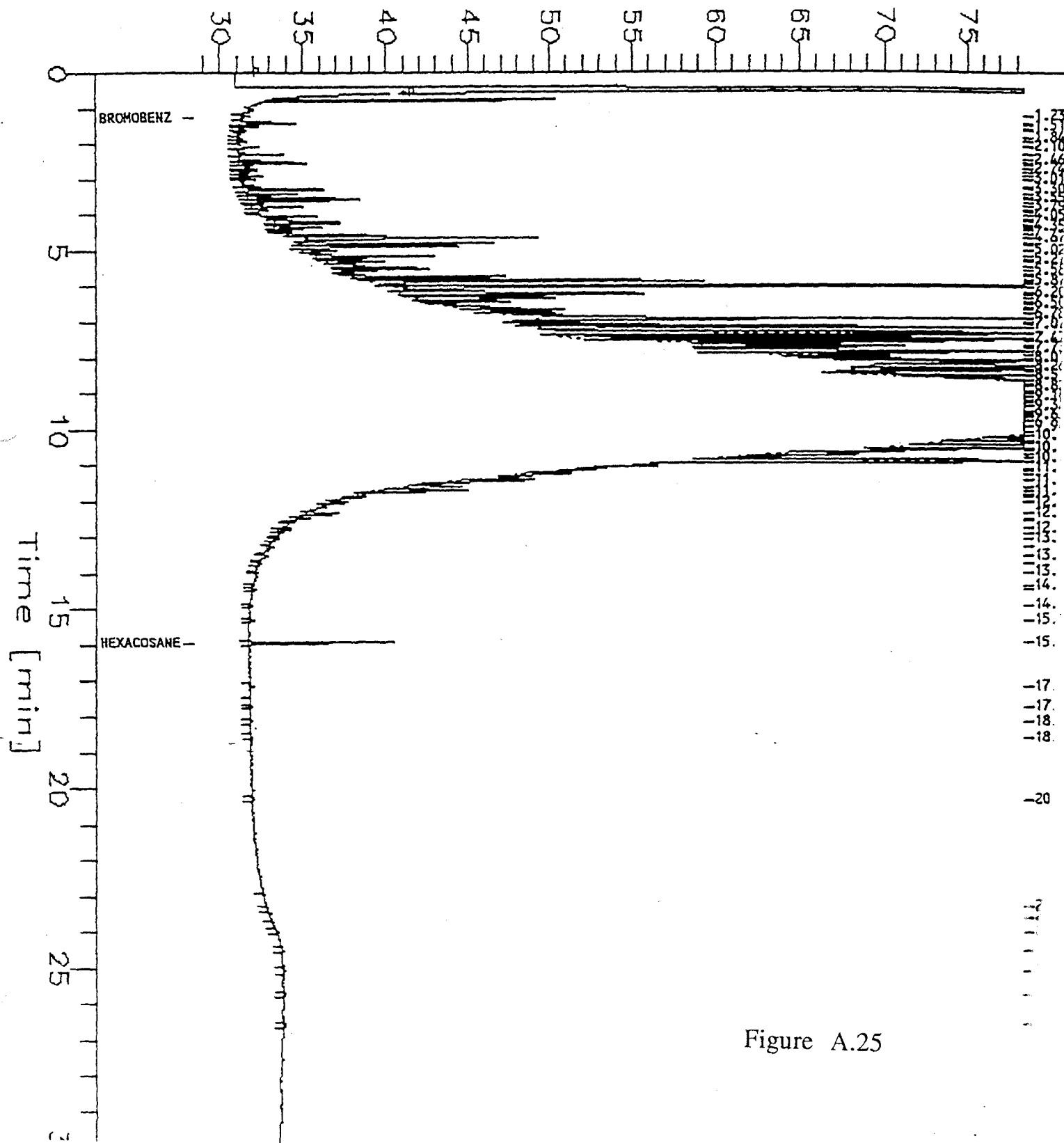


Figure A.25

## TEH Chromatogram GC11 CH B

Sample Name : 121433-010 300:1000

Sample #: 21532

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eName : g:\gc11\chb\188b009.raw

Date : 7/9/95 12:01 AM

.hod : GC11DUAL.ins

Time of Injection: 7/8/95 11:27 PM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 28.54 mV

High Point : 78.54 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

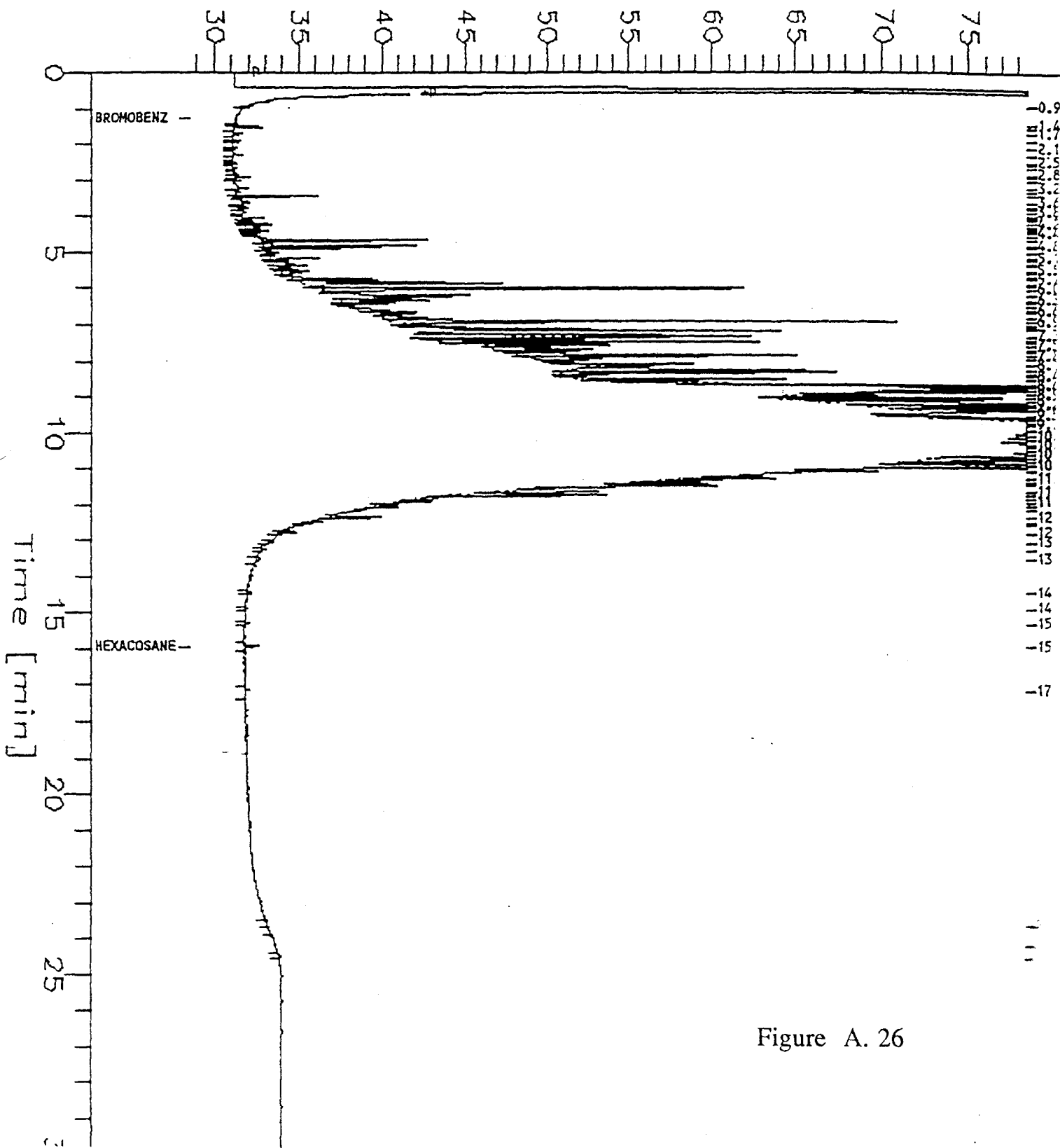


Figure A. 26

## TEH Chromatogram GC11 CH B

Sample Name : 121433-011 260:500

Sample #: 21532

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Name : g:\gc11\chb\188b010.raw

Date : 7/9/95 12:45 AM

Method : GC11DUAL.ins

Time of Injection: 7/9/95 12:11 AM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 28.96 mV

High Point : 78.96 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

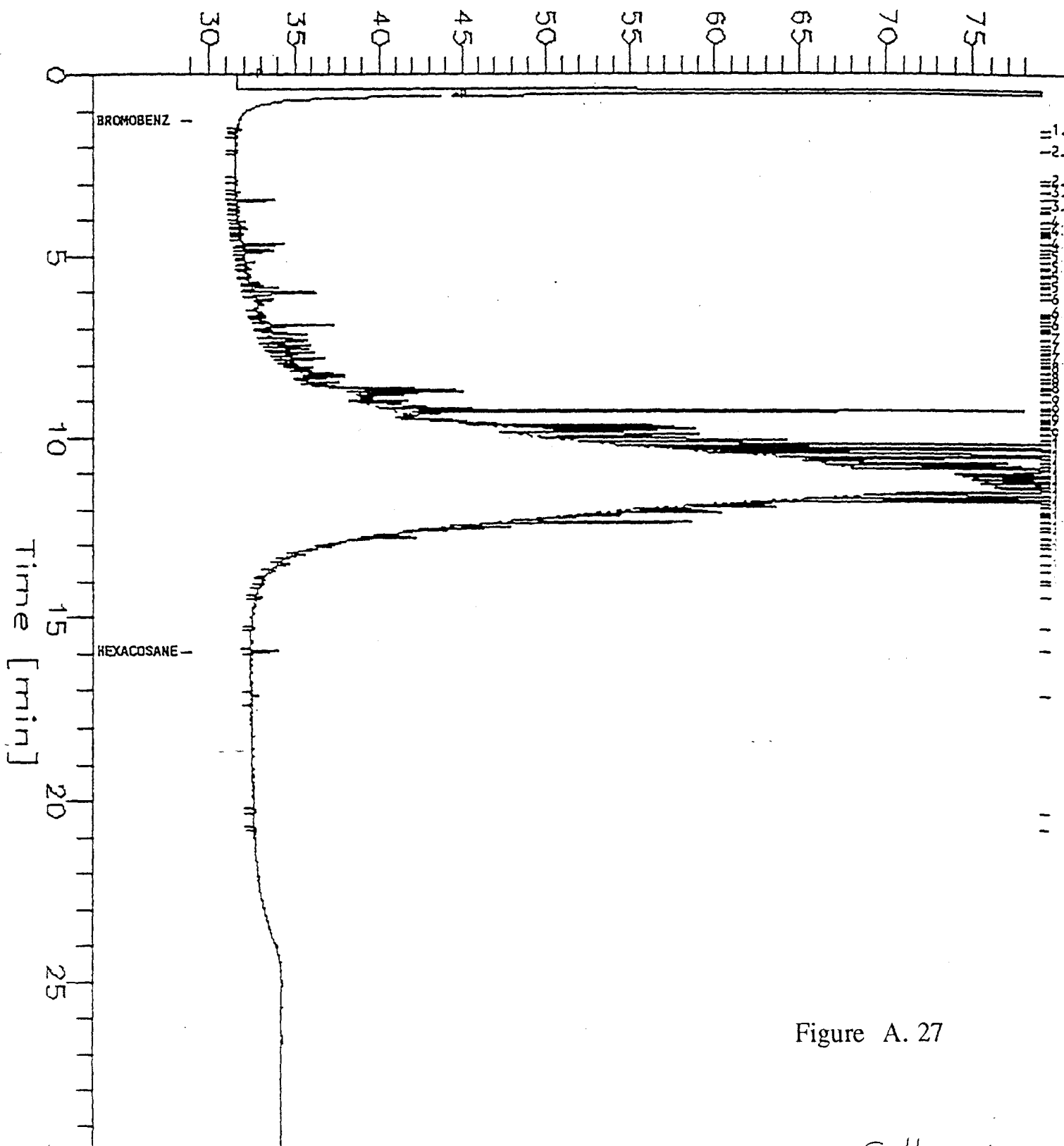


Figure A. 27

## TEH Chromatogram GC11 CH B

Le Name : 121433-012 130:250  
Name : g:\gc11\chb\188b011.raw  
Mod : GC11DUAL.ins  
Start Time : 0.00 min  
Scale Factor: -1

End Time : 31.92 min  
Plot Offset: 29 mV

Sample #: 21532  
Date : 7/9/95 01:30 AM  
Time of Injection: 7/9/95 12:55 AM  
Low Point : 29.04 mV  
Plot Scale: 50 mV

Page 1 of 1

Response [mV]

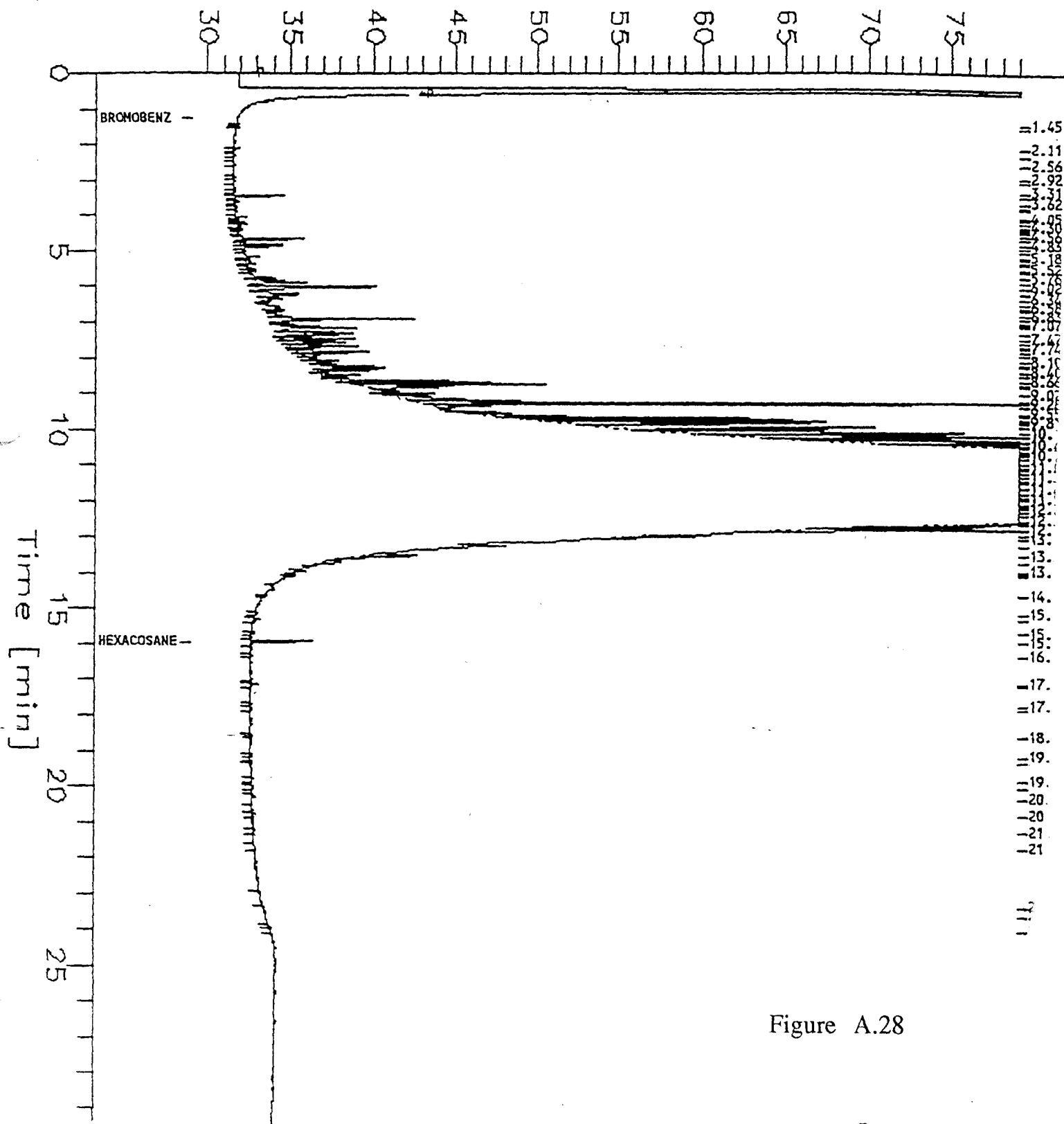


Figure A.28

Sample Name : 121433-013,500:25

Sample #: 21610

Page 1 of 1

FileName : g:\gc11\cha\198a008.raw

Date : 7/18/95 12:52 AM

Time of Injection: 7/18/95 12:20 AM

Mod : GC11DUAL.ins

Low Point : 28.58 mV

High Point : 78.58 mV

rt Time : 0.00 min

End Time : 31.92 min

Plot Scale: 50 mV

Scale Factor: -1

Plot Offset: 29 mV

Response [mV]

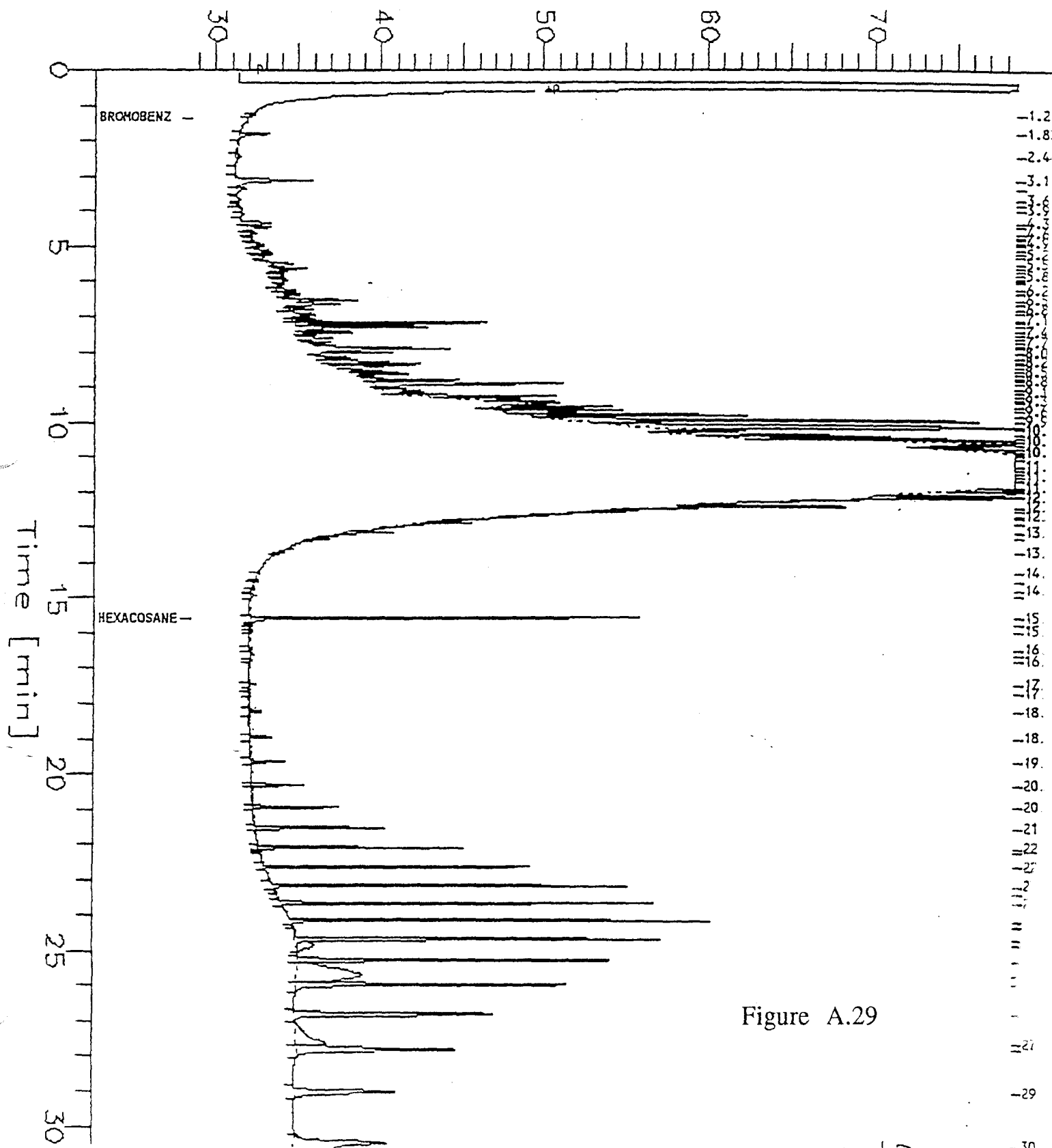


Figure A.29

## TEH Chromatogram GC11 CH A

Sample Name : 121433-014 440:100

Sample #: 21558

Page 1 of 1

FileName : g:\gc11\cha\188a036.raw

Date : 7/9/95 10:18 PM

Mod : GC11DUAL.ins

Time of Injection: 7/9/95 09:46 PM

Art Time : 0.00 min

End Time : 31.92 min

Low Point : 26.73 mV

High Point : 76.73 mV

Scale Factor: -1

Plot Offset: 27 mV

Plot Scale: 50 mV

Response [mV]

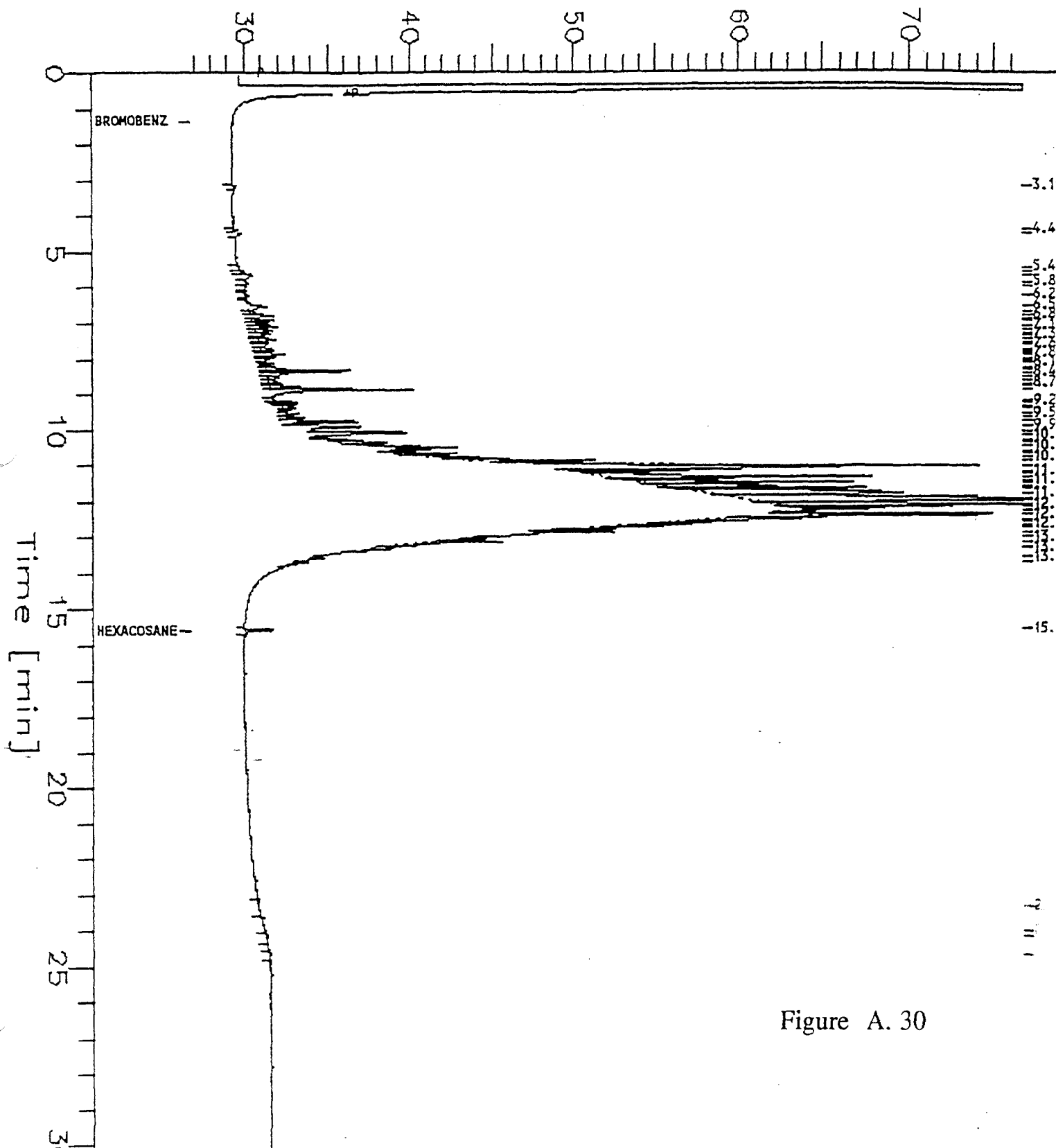


Figure A. 30

## TEH Chromatogram GC11 CH A

File Name : 121433-015 410:250

Sample #: 21558

Page 1 of 1

eName : g:\gc11\cha\188a037.raw

Date : 7/9/95 11:02 PM

Method : GC11DUAL.ins

Time of Injection: 7/9/95 10:30 PM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 27.20 mV

High Point : 77.20 mV

Scale Factor: -1

Plot Offset: 27 mV

Plot Scale: 50 mV

Response [mV]

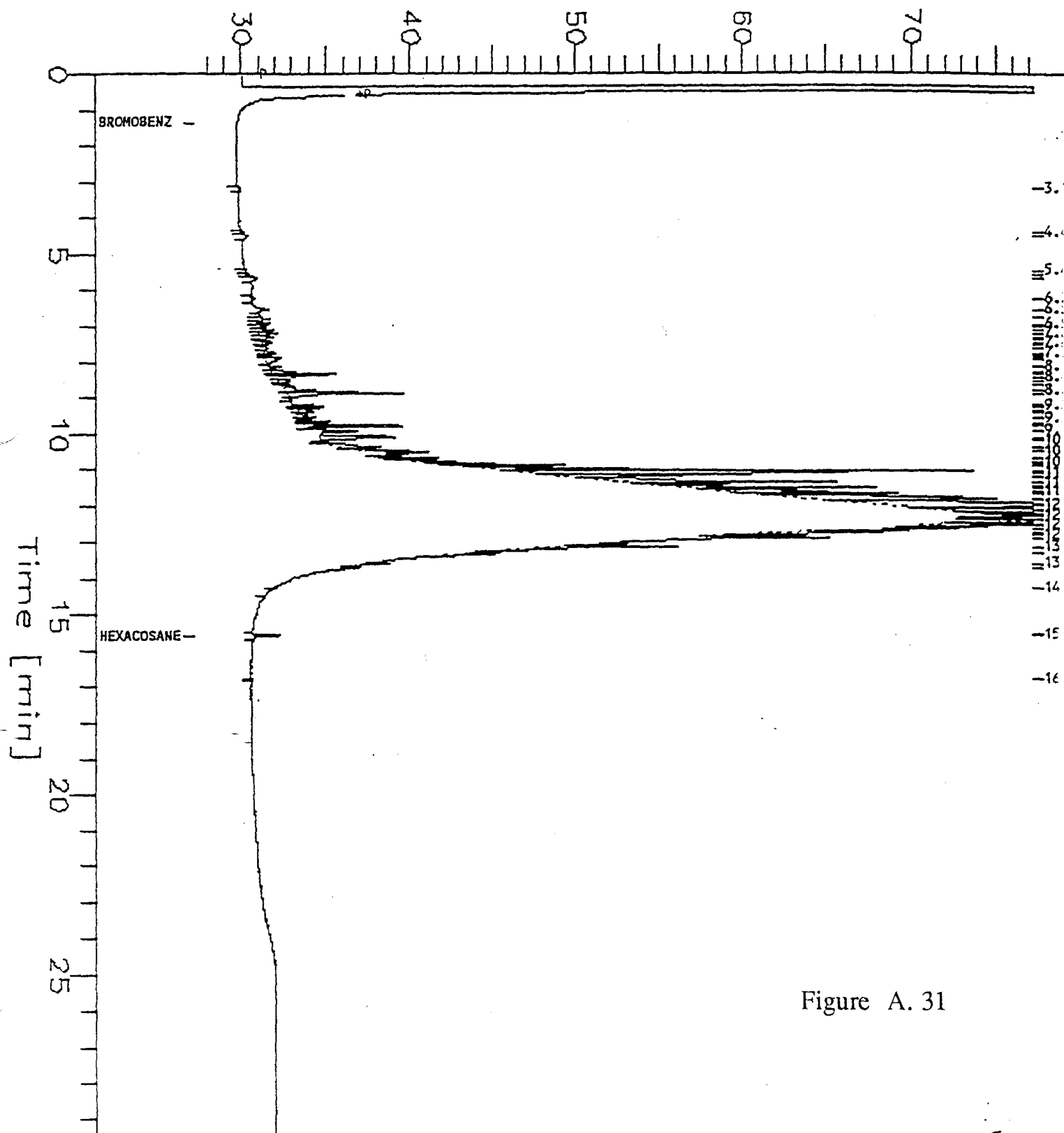


Figure A. 31

## TEH Chromatogram GC11 CH A

Name : 121433-016 450:250  
Name : G:\GC11\CHA\203a007.raw  
od : GC11DUAL.ins  
t Time : 0.00 min  
Scale factor: -1

End Time : 31.92 min  
Plot Offset: 28 mV

Sample #: 21558rerun  
Date : 7/24/95 12:03 PM  
Time of Injection: 7/23/95 1:28 AM  
Low Point : 28.35 mV  
Plot Scale: 50 mV  
High Point : 78.35 mV

Page 1 of 1

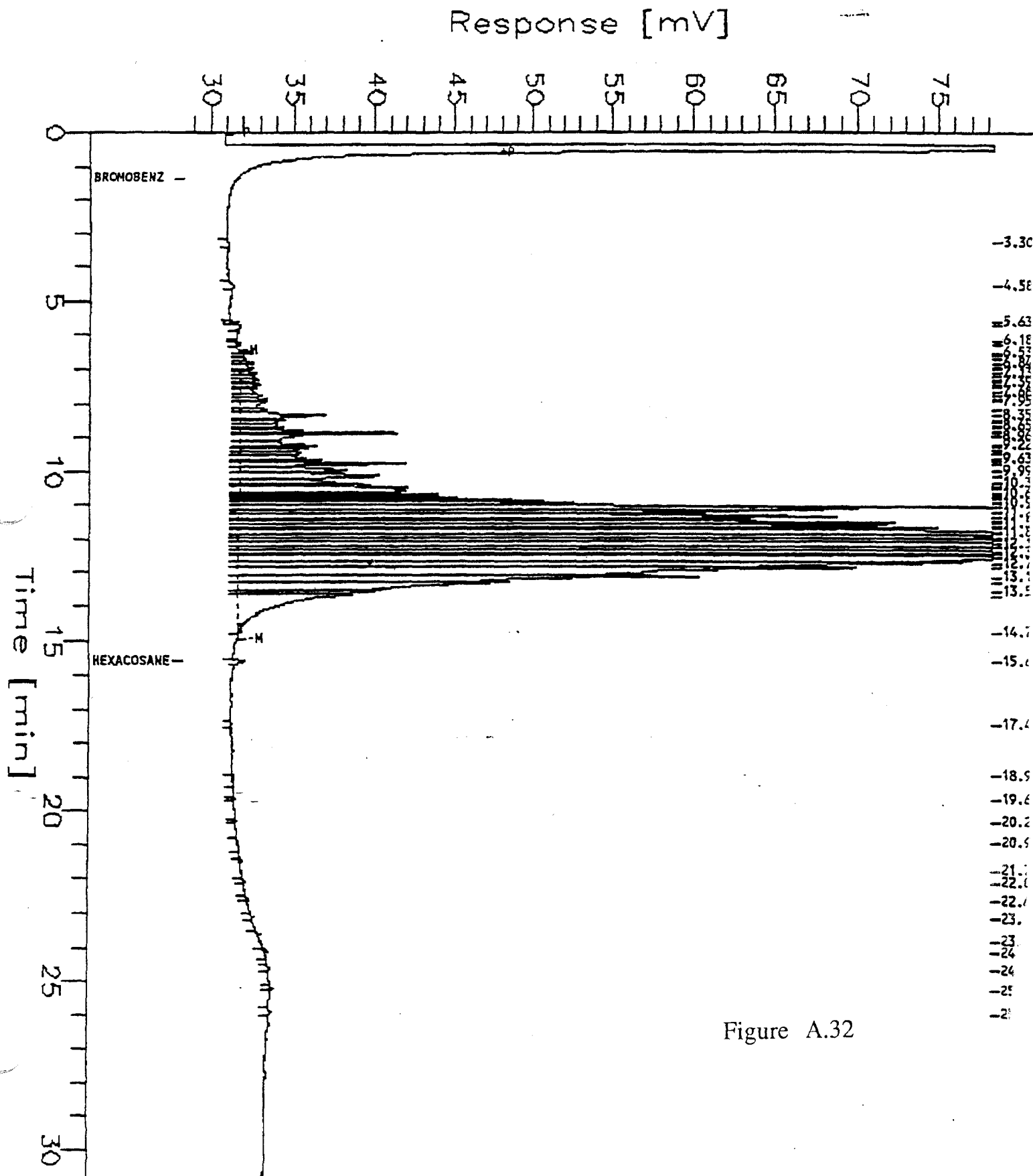


Figure A.32



## TEH Chromatogram GC15 CH A

Sample Name : 121433-017 430:50

Sample #: 21558

Page 1 of 1

Name : g:\gc15\cha\181A094.raw

Date : 7/3/95 5:31 AM

od : TEH\_CHA.ins

Time of Injection: 7/3/95 4:56 AM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 28.90 mV

High Point : 78.90 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

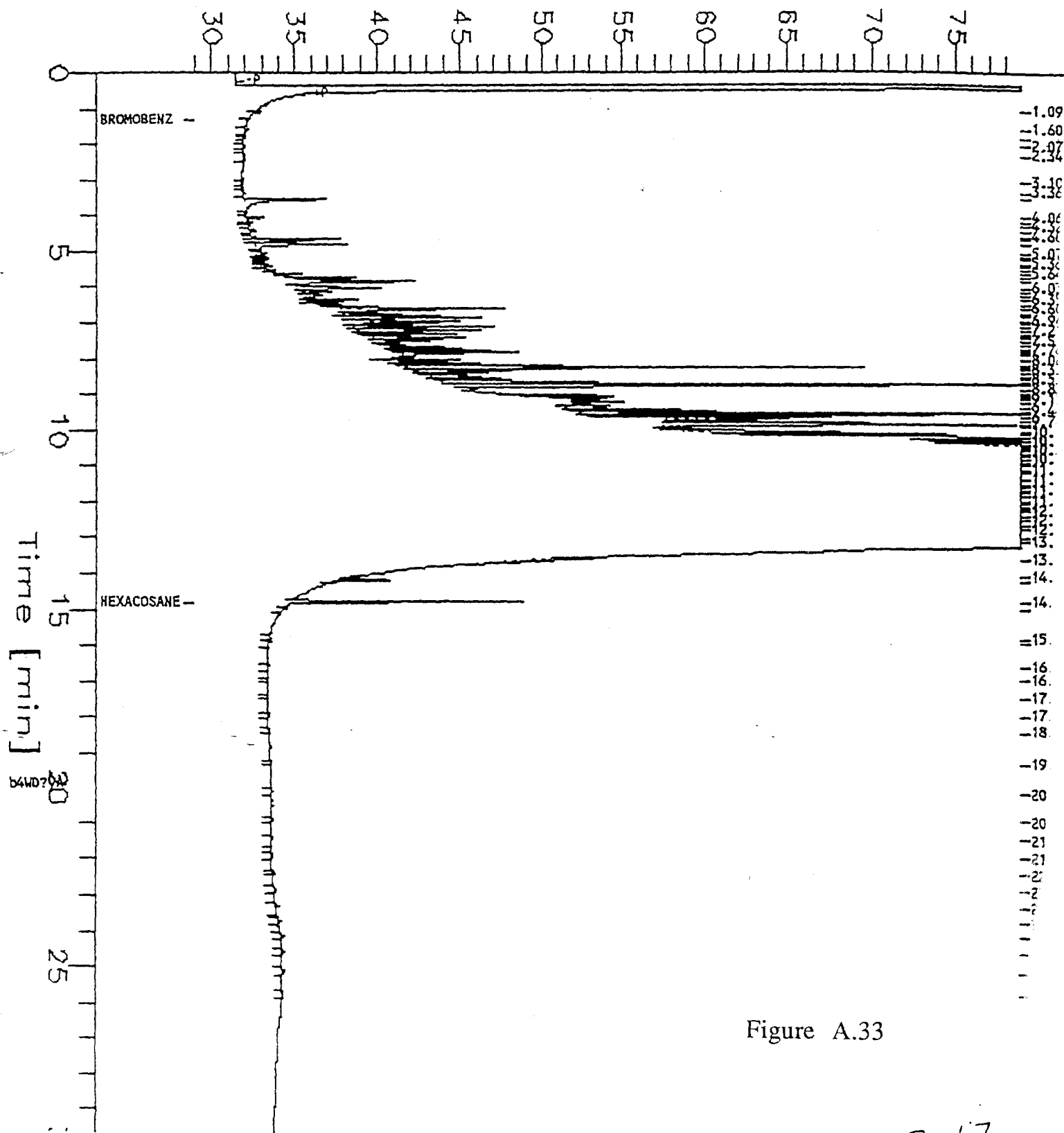


Figure A.33

## TEH Chromatogram GC11 CH B

Sample Name : 121433-018 500:250

Sample #: 21432

Page 1 of 1

eName : g:\gc11\chb\188b019.raw

Date : 7/9/95 07:20 AM

.hod : GC11DUAL.ins

Time of Injection: 7/9/95 06:45 AM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 28.71 mV

High Point : 78.71 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

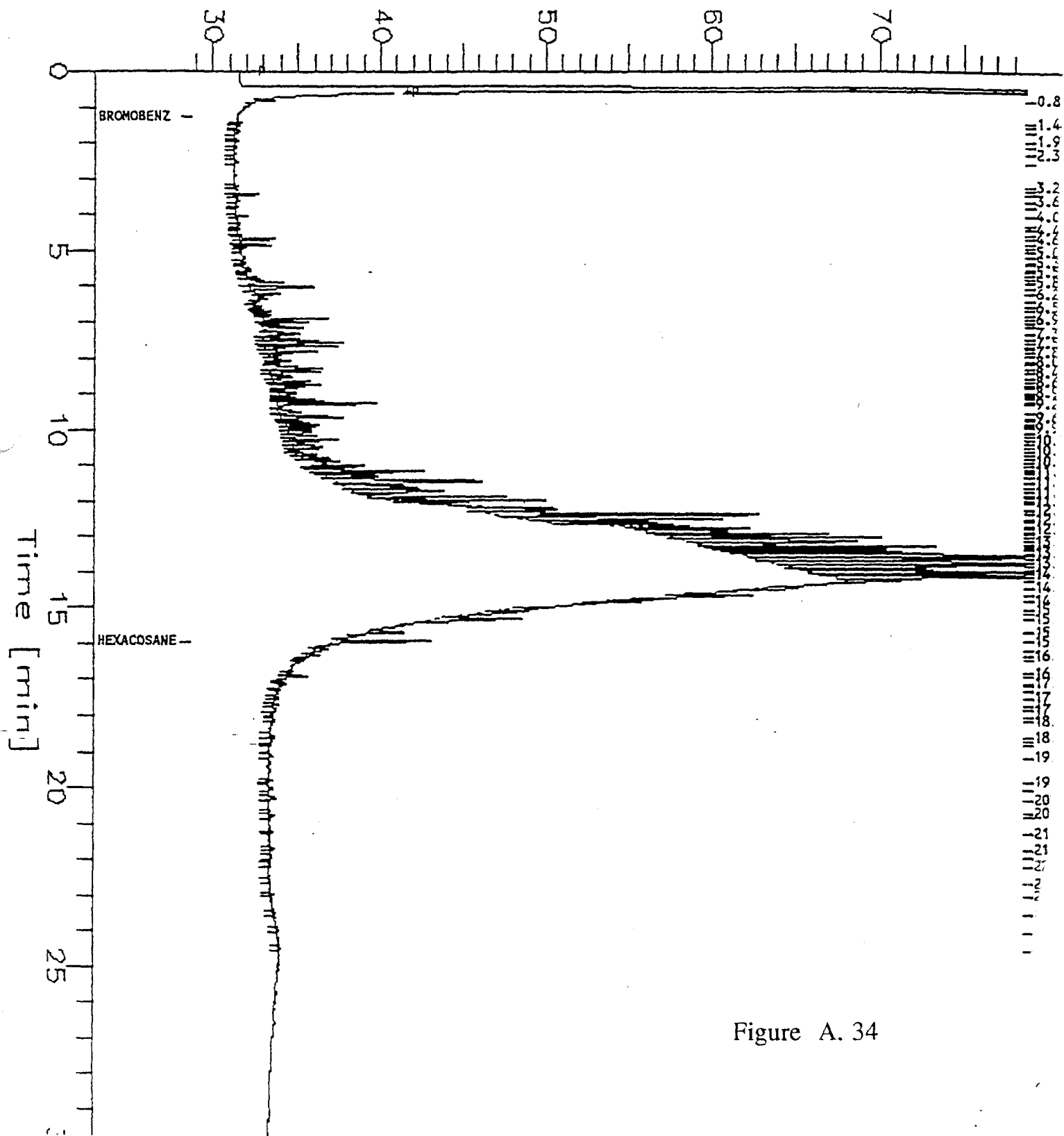


Figure A. 34

Sample Name : 121433-019 500:25

Sample #: 21432

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File Name : g:\gc11\chb\188b022.raw

Date : 7/9/95 09:31 AM

Mod : GC11DUAL.ins

Time of Injection: 7/9/95 08:57 AM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 28.70 mV

High Point : 78.70 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

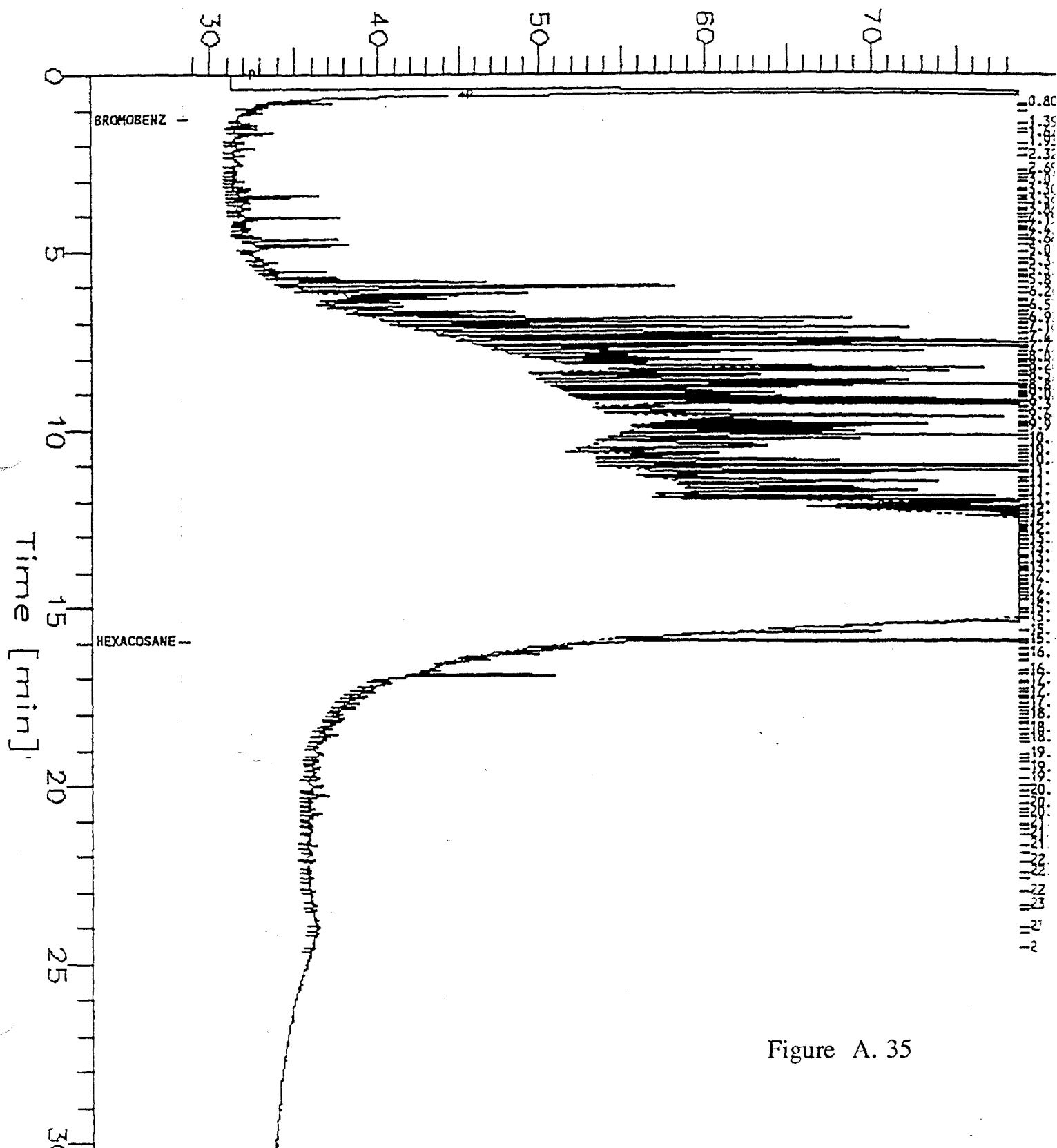


Figure A. 35

Sample Name : 121433-020 500:25

Sample #: 21432

Page 1 of 1

FileName : g:\gc11\chb\188b023.raw

Date : 7/9/95 10:15 AM

Method : GC11DUAL.ins

Time of Injection: 7/9/95 09:41 AM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 28.32 mV

High Point : 78.32 mV

Scale Factor: -1

Plot Offset: 28 mV

Plot Scale: 50 mV

Response [mV]

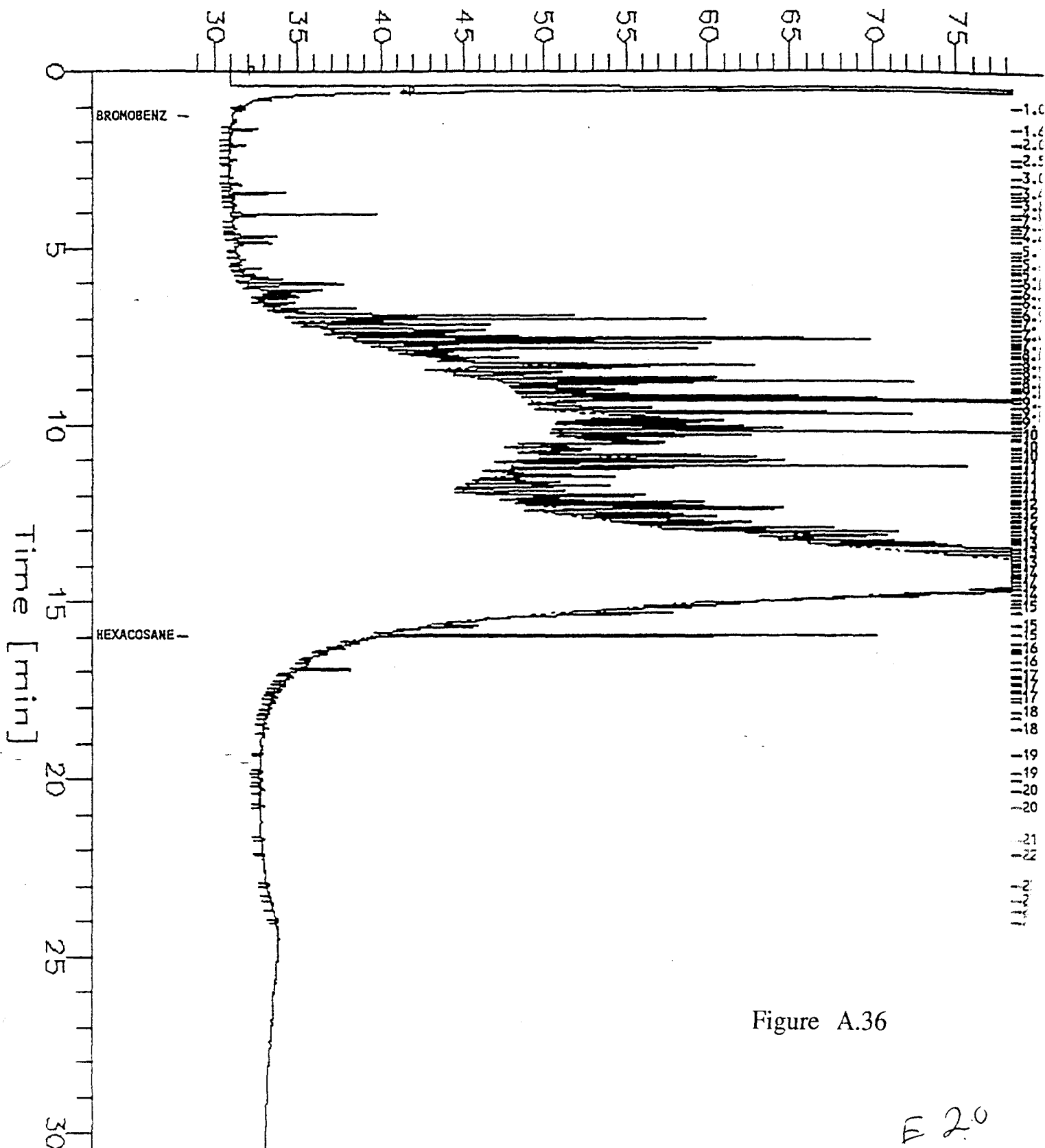


Figure A.36

E 20

Sample Name : 121433-021 500:25

FileName : g:\gc11\chb\188b024.raw

Method : GC11DUAL.ins

Start Time : 0.00 min

Scale Factor: -1

End Time : 31.92 min

Plot Offset: 28 mV

Sample #: 21432

Date : 7/9/95 10:58 AM

Time of Injection: 7/9/95 10:25 AM

Low Point : 28.20 mV

Plot Scale: 50 mV

Page 1 of 1

High Point : 78.20 mV

Response [mV]

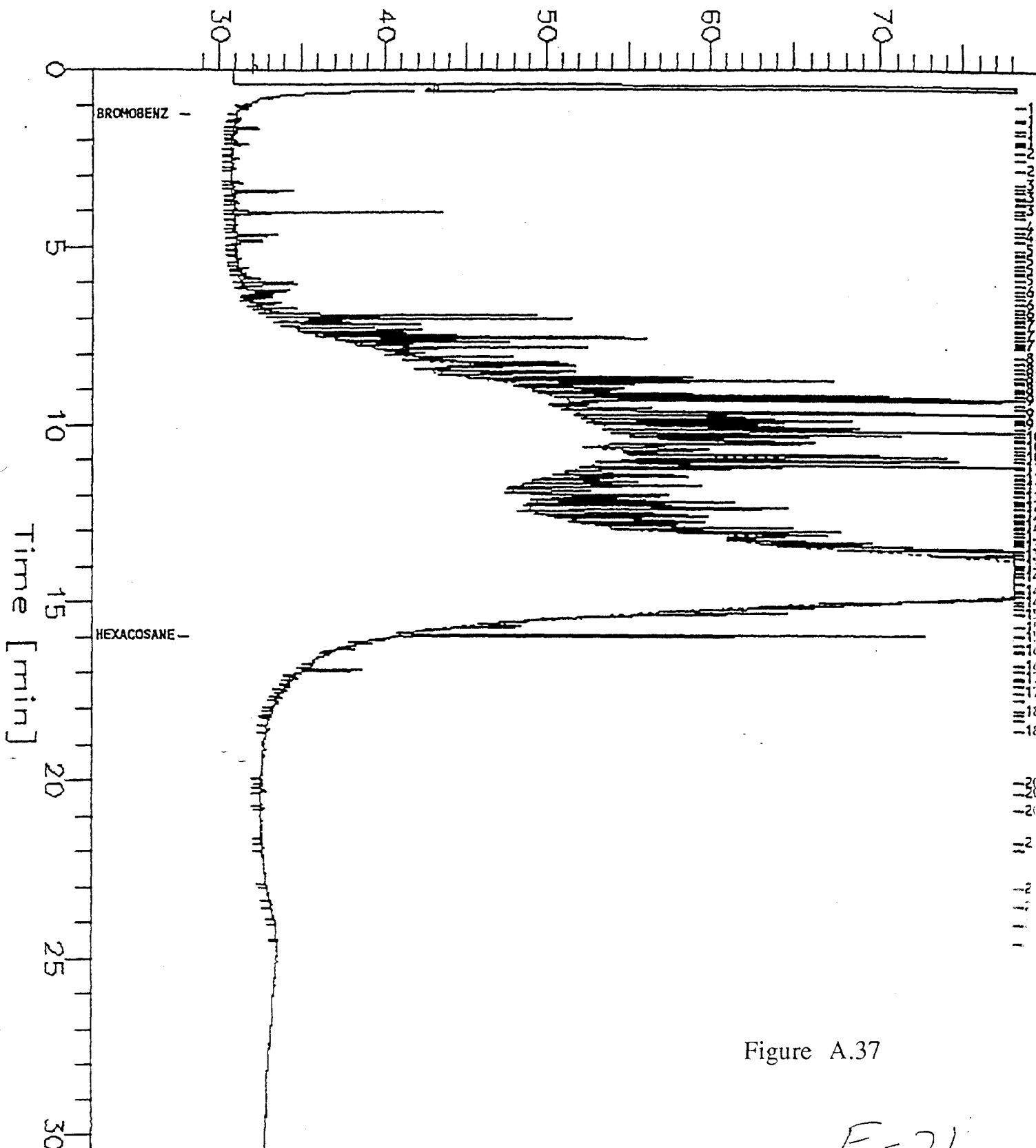


Figure A.37

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## TEH Chromatogram GC11 CH B

Sample Name : 121433-022 500:25  
FileName : g:\gc11\chb\188b026.raw  
Method : GC11DUAL.ins  
Start Time : 0.00 min  
Scale Factor : -1.

End Time : 31.92 min  
Plot Offset: 28 mV

Sample #: 21432  
Date : 7/9/95 12:26 PM  
Time of Injection: 7/9/95 11:53 AM  
Low Point : 28.08 mV  
Plot Scale: 50 mV

Page 1 of 1

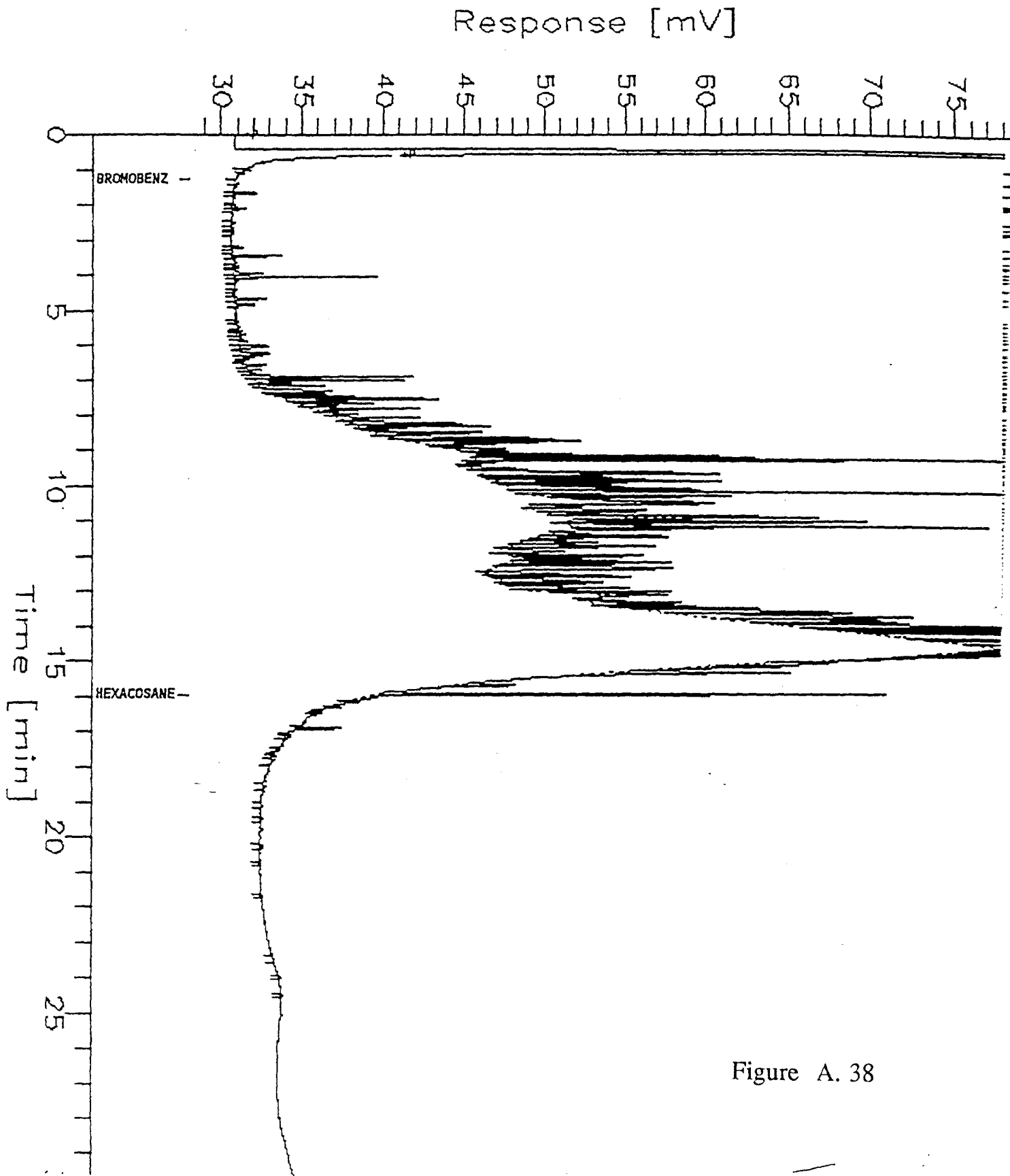


Figure A. 38

Sample Name : 121433-023 500:25

FileName : g:\gc11\chb\188b028.raw

Method : GC11DUAL.ins

rt Time : 0.00 min

e Factor: -1

End Time : 31.92 min

Plot Offset: 37 mV

Sample #: 21432

Date : 7/9/95 01:54 PM

Time of Injection: 7/9/95 01:20 PM

Low Point : 37.36 mV

Plot Scale: 50 mV

Page 1 of 1

High Point : 87.36 mV

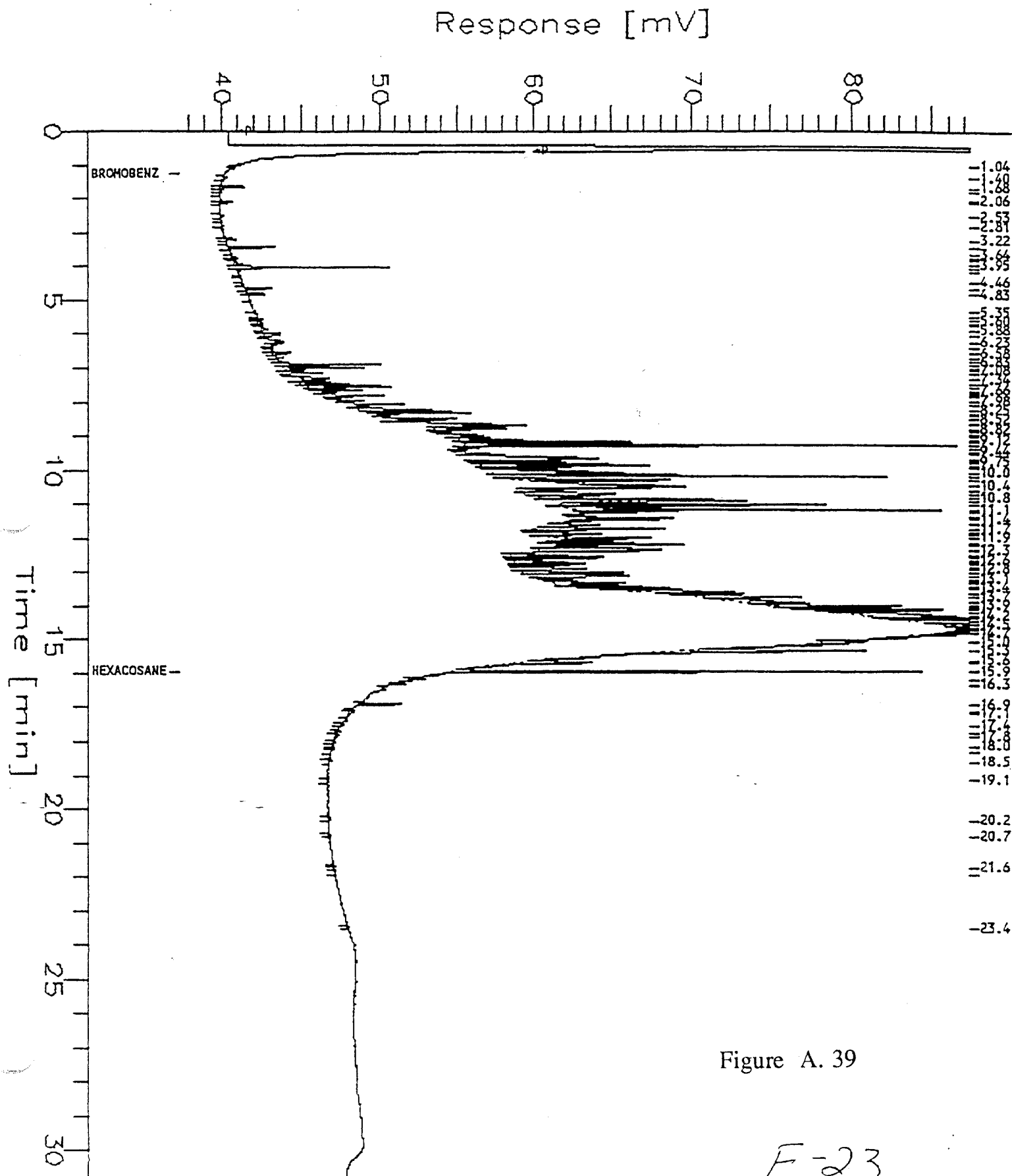


Figure A. 39

F-23

JUL 17 '95 14:44 C&T

TEH Chromatogram GC11 CH B

P.41

Sample Name : 121433-024 500:25

Sample #: 21432

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File Name : g:\gc11\chb\188b033.raw

Date : 7/9/95 05:33 PM

Method : GC11DUAL.ins

Time of Injection: 7/9/95 05:00 PM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 29.20 mV

High Point : 79.20 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

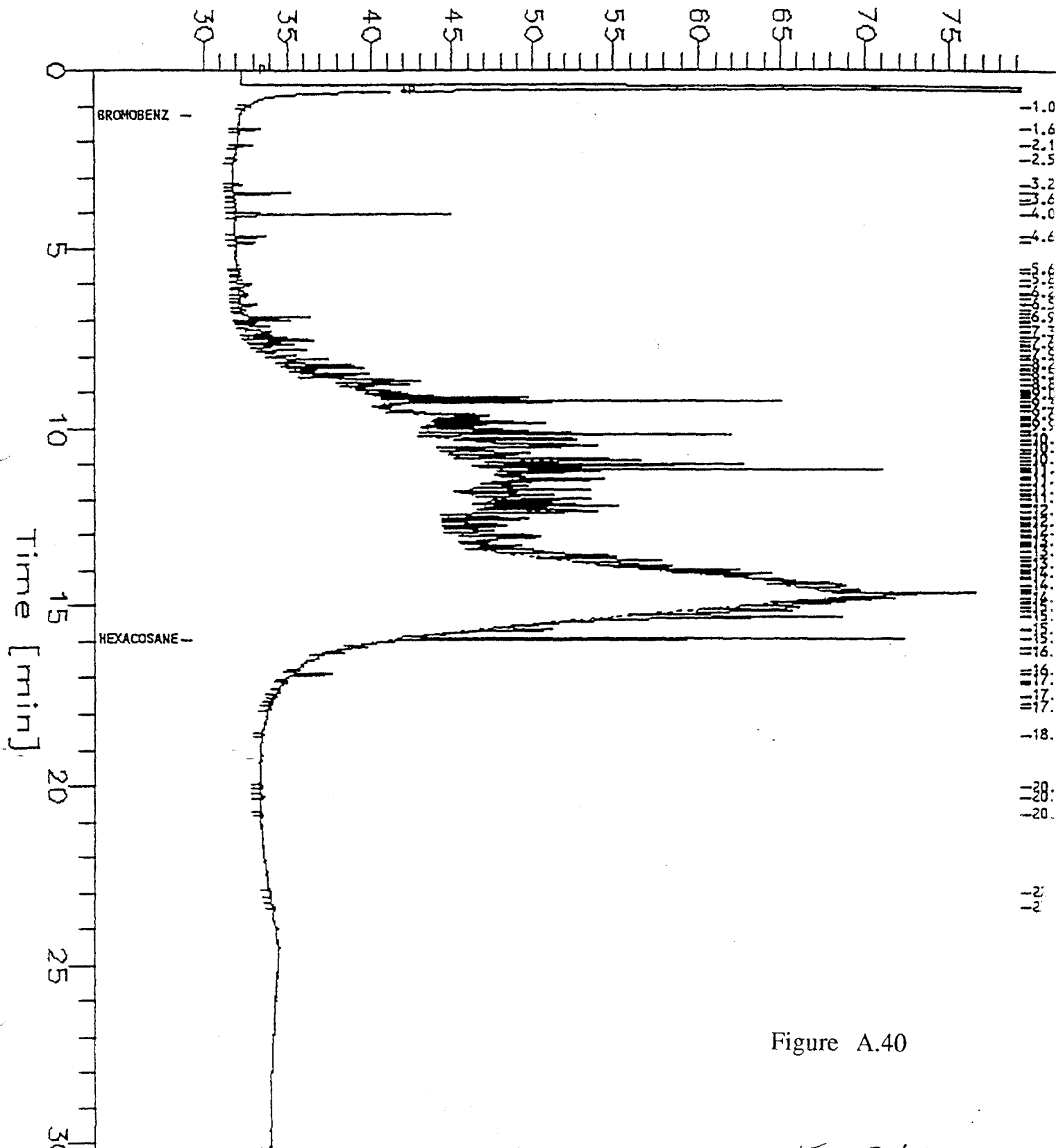


Figure A.40



JUL 17 '95 14:45 C&T

TEH Chromatogram GC11 CH A

P.42

Sample Name : 121433-025,500:125  
LeName : G:\GC11\CHB\1948039.RAW  
Method : GC11DUAL.ins  
Start Time : 0.00 min  
Scale Factor: -1

End Time : 31.92 min  
Plot Offset: 28 mV

Sample #: 21432  
Date : 7/15/95 12:55 PM  
Time of Injection: 7/14/95 10:01 PM  
Low Point : 28.42 mV  
Plot Scale: 50 mV  
High Point : 78.42 mV

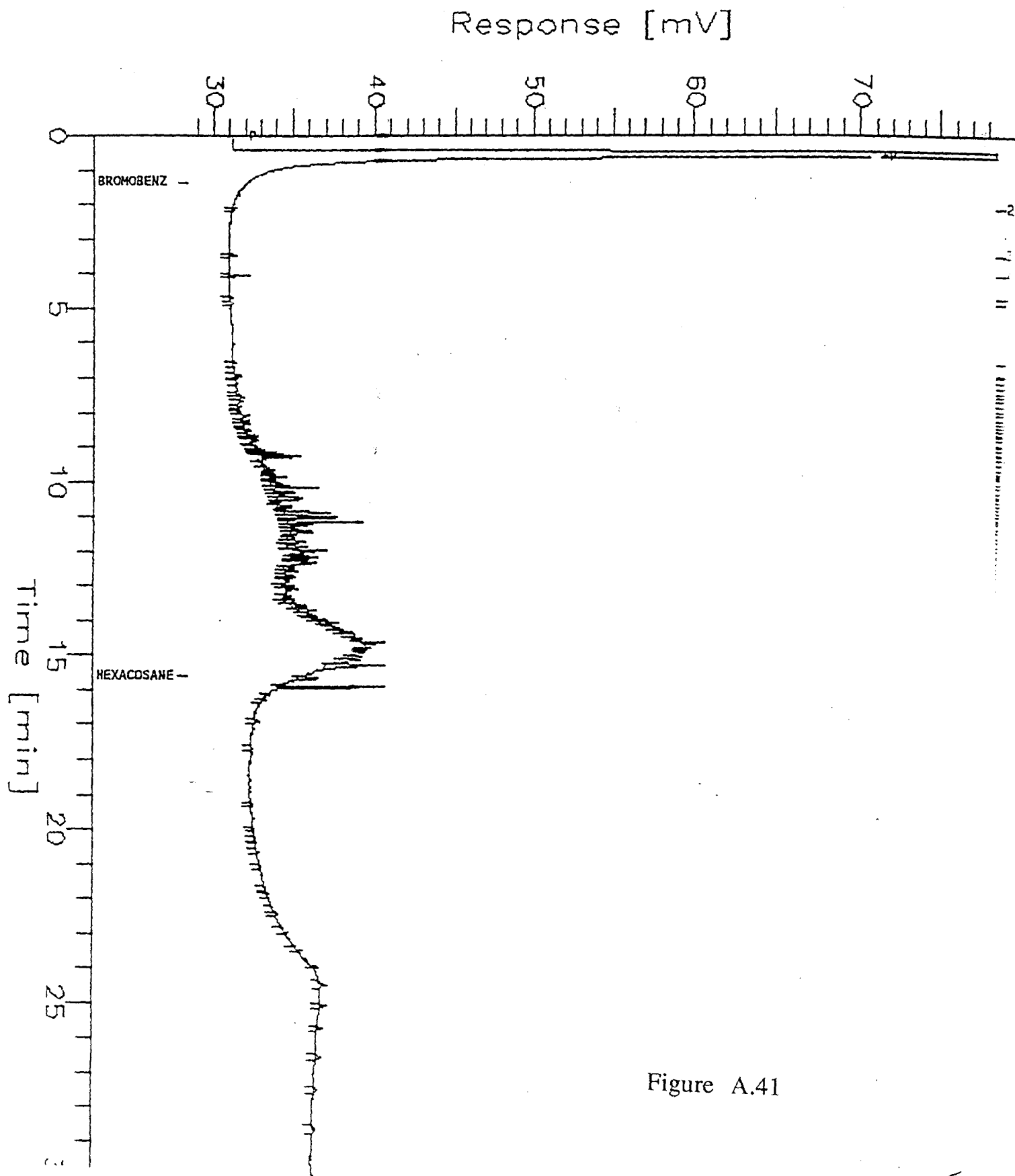


Figure A.41

E-25

JUL 17 '95 14:45 C&T

TEH Chromatogram GC11 CH B

P.43

Sample Name : 121433-026 500:25

File Name : G:\GC11\CHB\188b037.raw

Method : GC11DUAL.ins

Start Time : 0.00 min

Scale Factor : -1

End Time : 31.92 min

Plot Offset : 29 mV

Sample #: 21432

Date : 7/13/95 10:45 PM

Time of Injection: 7/9/95 10:30 PM

Low Point : 28.89 mV

Plot Scale: 50 mV

Page 1 of 1

High Point : 78.89 mV

Response [mV]

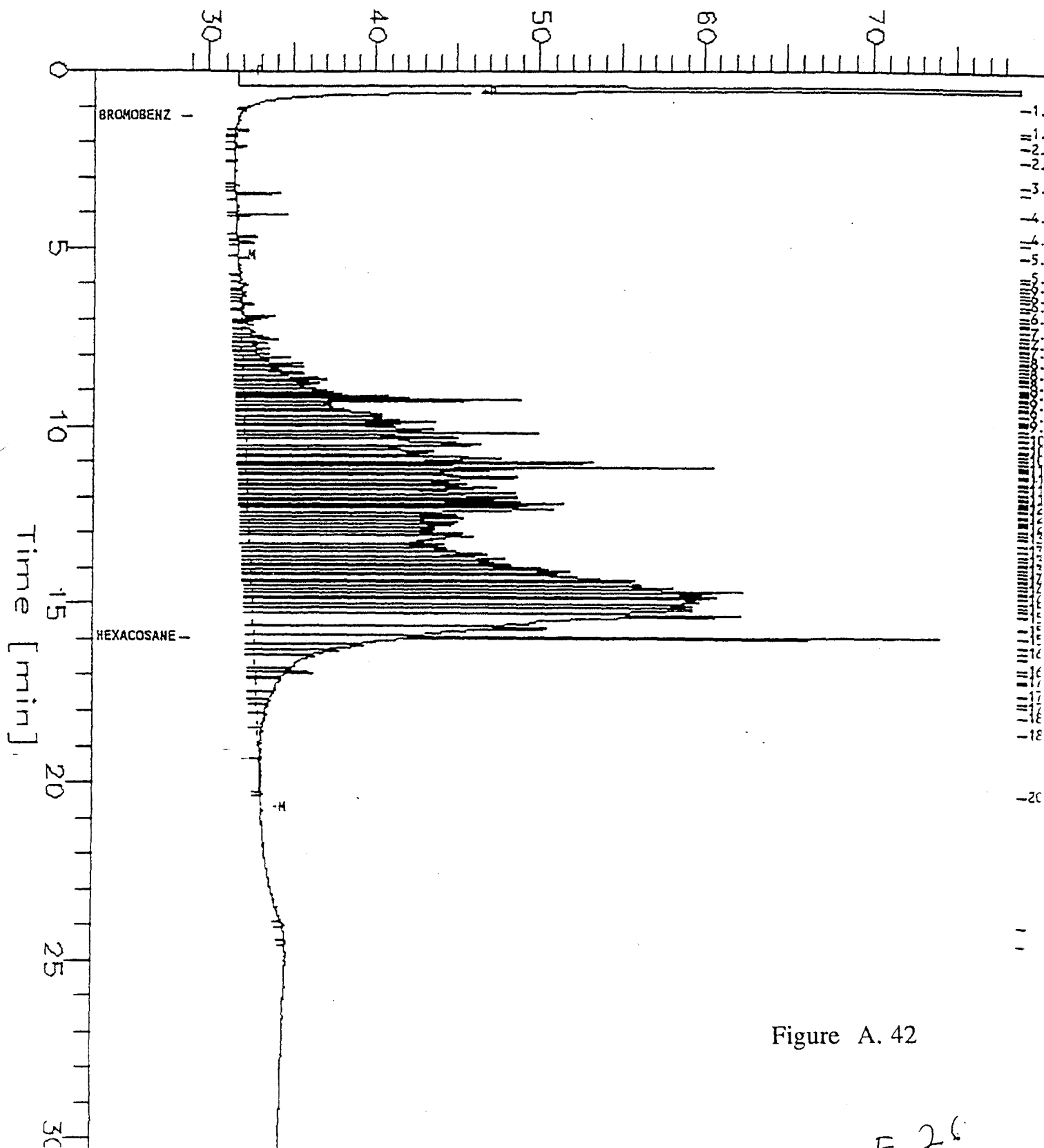


Figure A. 42

E 26

## TEH Chromatogram GC15 CH A

Sample Name : 121433-027 500:50

FileName : g:\gc15\cha\181A093.raw

Method : TEH\_CHA.ins

Start Time : 0.00 min

Scale Factor: -1

End Time : 31.92 min

Plot Offset: 29 mV

Sample #: 21558

Date : 7/3/95 4:47 AM

Time of Injection: 7/3/95 4:13 AM

Low Point : 29.18 mV

Plot Scale: 50 mV

Page 1 of 1

High Point : 79.18 mV

Response [mV]

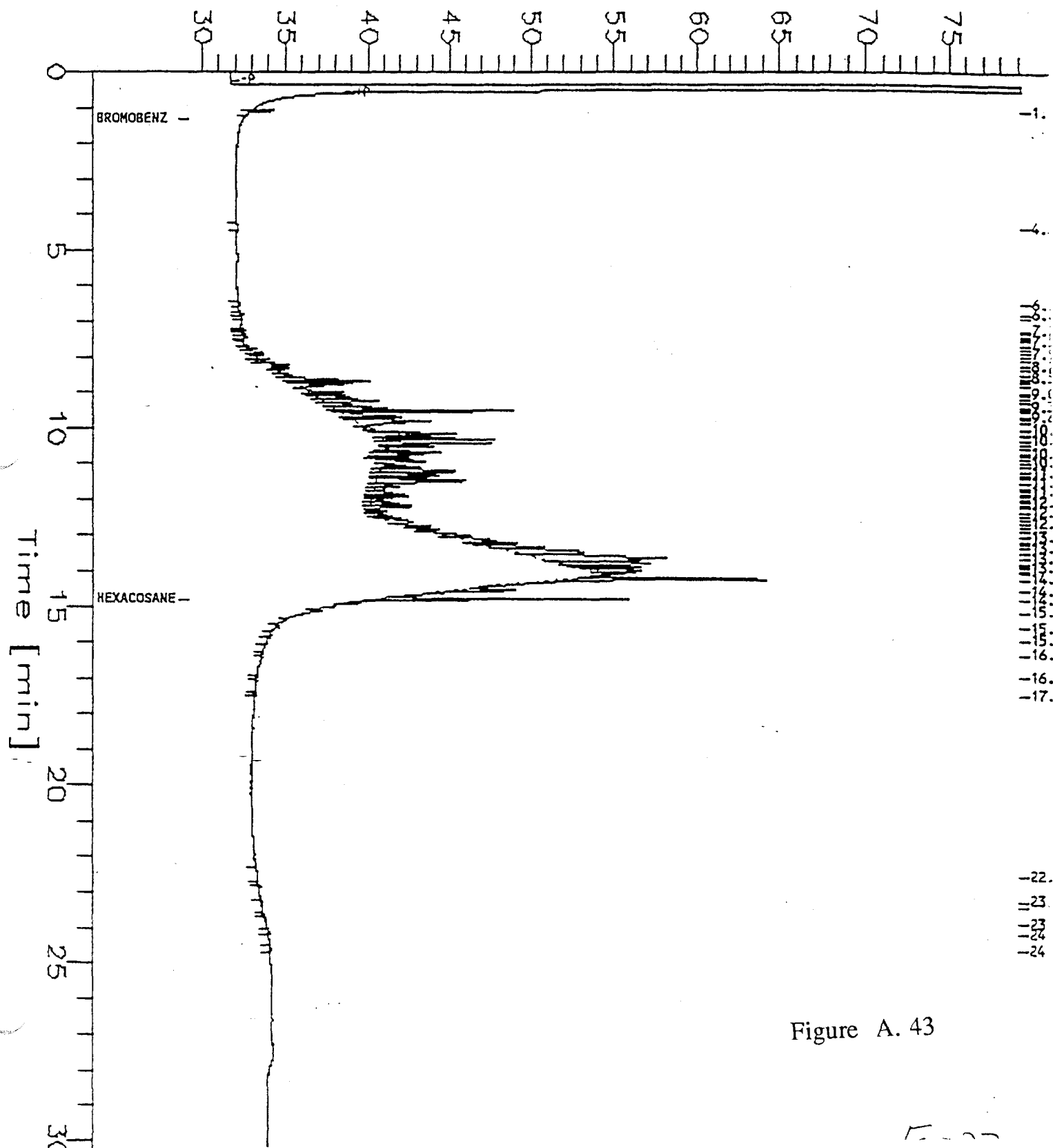


Figure A. 43

## TEH Chromatogram GC15 CH A

Sample Name : 121433-028 500:50

Sample #: 21558

Page 1 of 1

eName : g:\gc15\cha\181A091.raw

Date : 7/3/95 3:21 AM

Mod : TEH\_CHA.ins

Time of Injection: 7/3/95 2:46 AM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 29.09 mV

High Point : 79.09 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

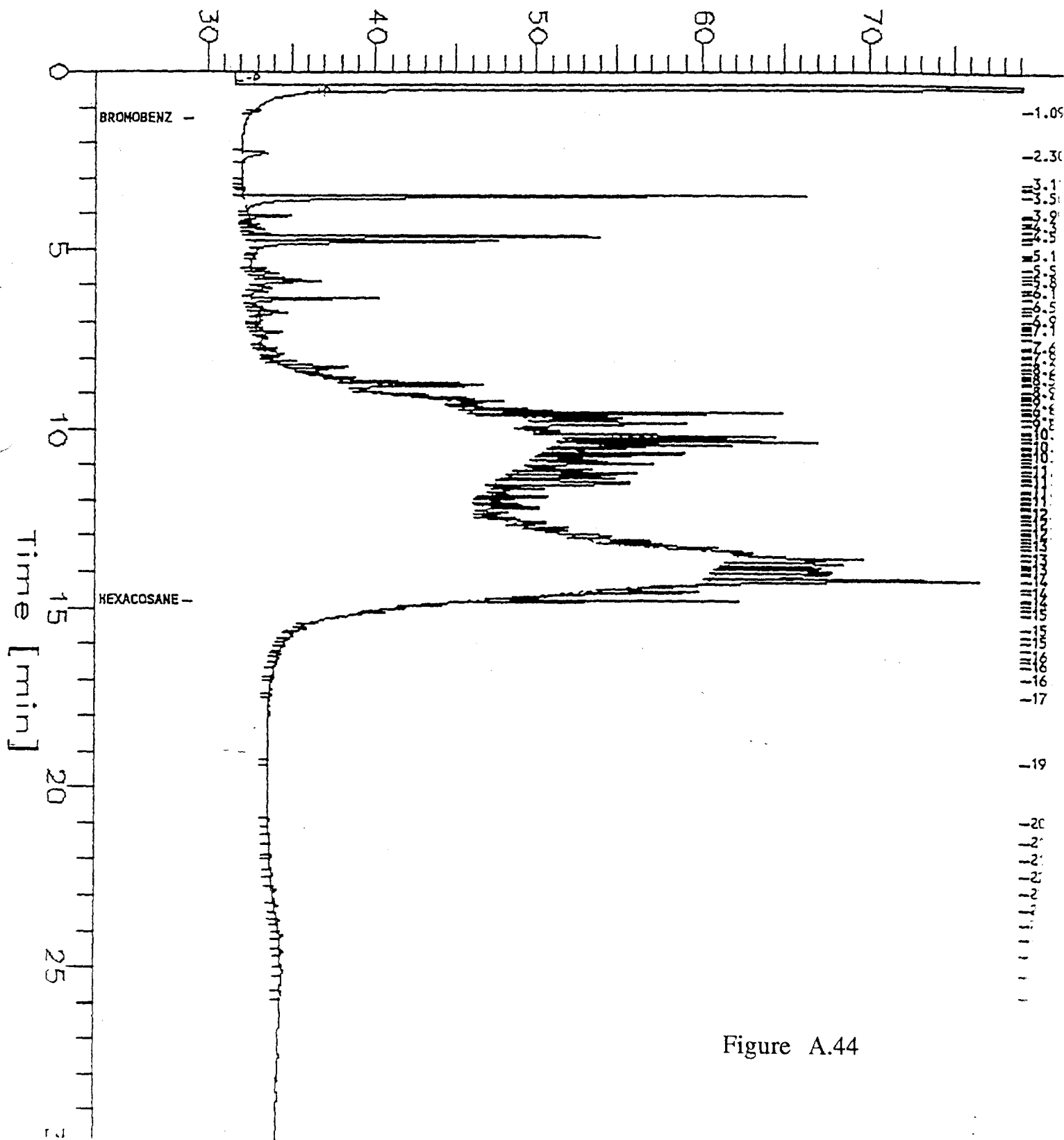


Figure A.44

JUL 11 '95 14:47 C&amp;T

Sample Name : 121433-029 38:2.5

FileName : g:\gc11\cha\188a020.raw

Method : GC11DUAL.ins

Start Time : 0.00 min

End Time : 31.92 min

Scale Factor : -1

Plot Offset: 28 mV

Sample #: 21710

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Date : 7/9/95 08:02 AM

Time of Injection: 7/9/95 07:29 AM

Low Point : 27.46 mV

High Point : 77.46 mV

Plot Scale: 50 mV

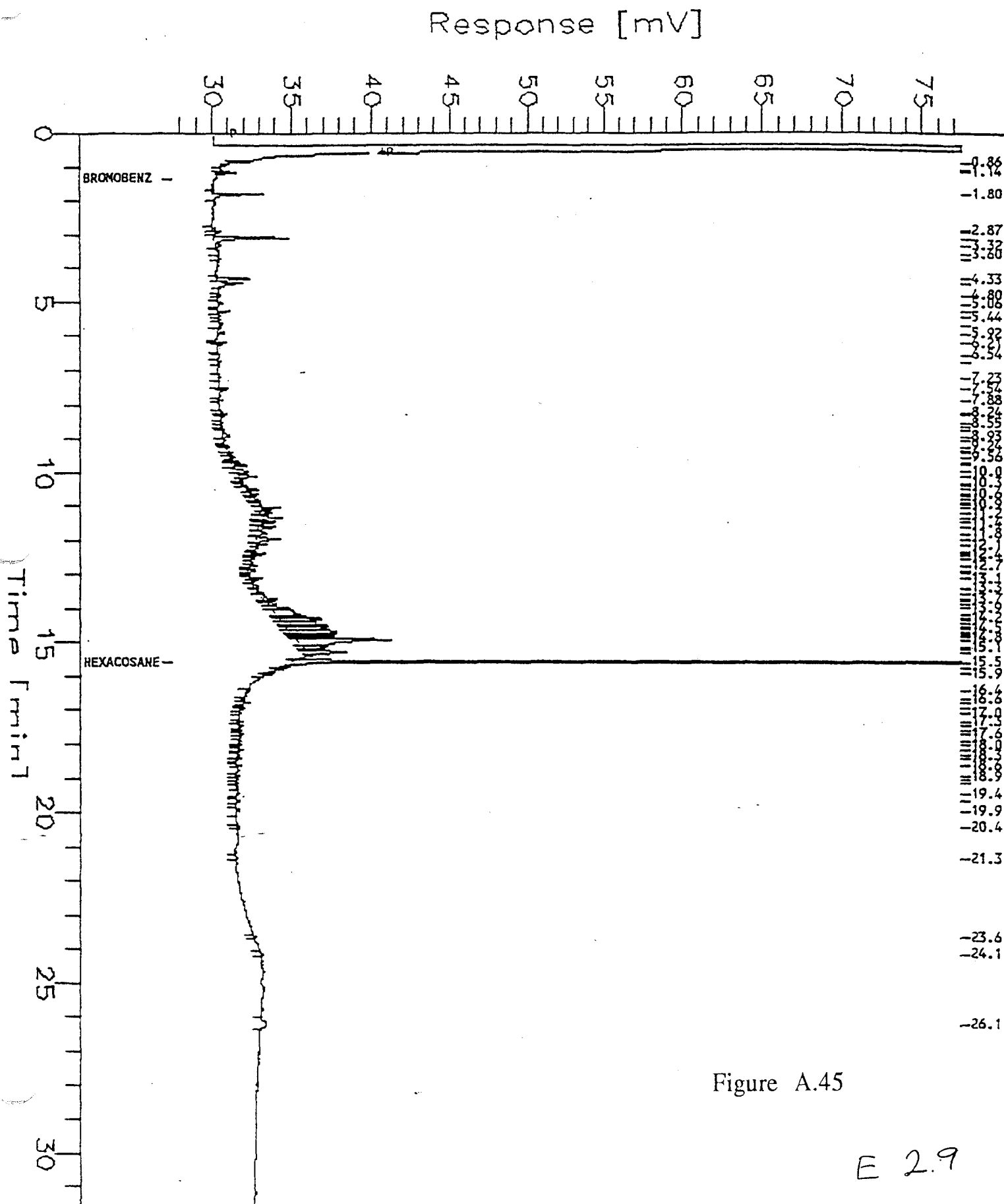


Figure A.45

E 2.9

Sample Name : 121433-030 500:50

Sample #: 21558

Page 1 of 1

FileName : g:\gc15\cha\181A090.raw

Date : 7/3/95 2:38 AM

Method : TEH\_CHA.ins

Time of Injection: 7/3/95 2:03 AM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 29.08 mV

High Point : 79.08 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

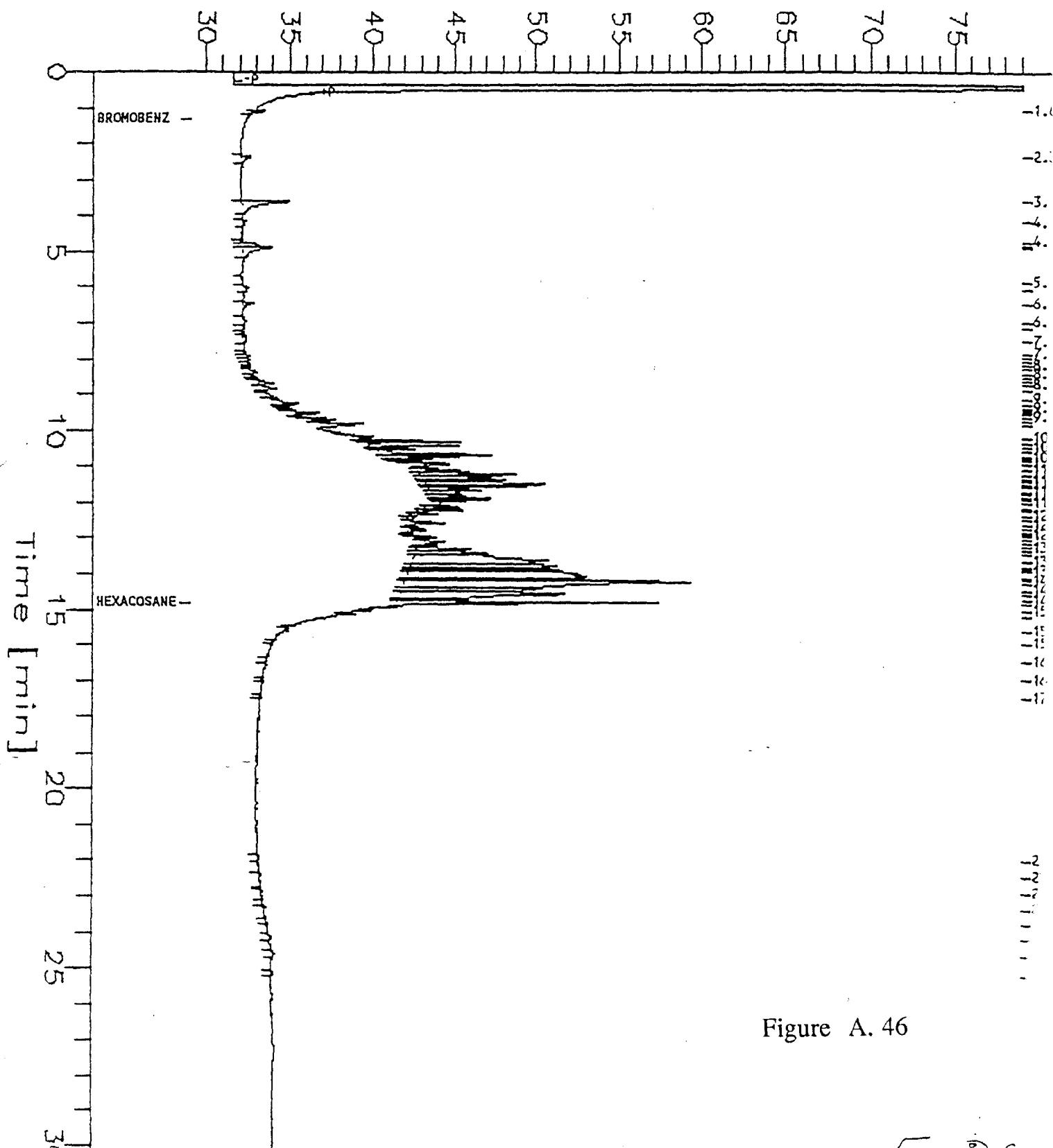


Figure A. 46

F-20

## TEH Chromatogram GC15 CH A

Sample Name : 121433-031 500:50

Sample #: 21558

Page 1 of 1

FileName : g:\gc15\cha\181A096.raw

Date : 7/3/95 6:58 AM

Method : TEH\_CHA.ins

Time of Injection: 7/3/95 6:23 AM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 28.82 mV

High Point : 78.82 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

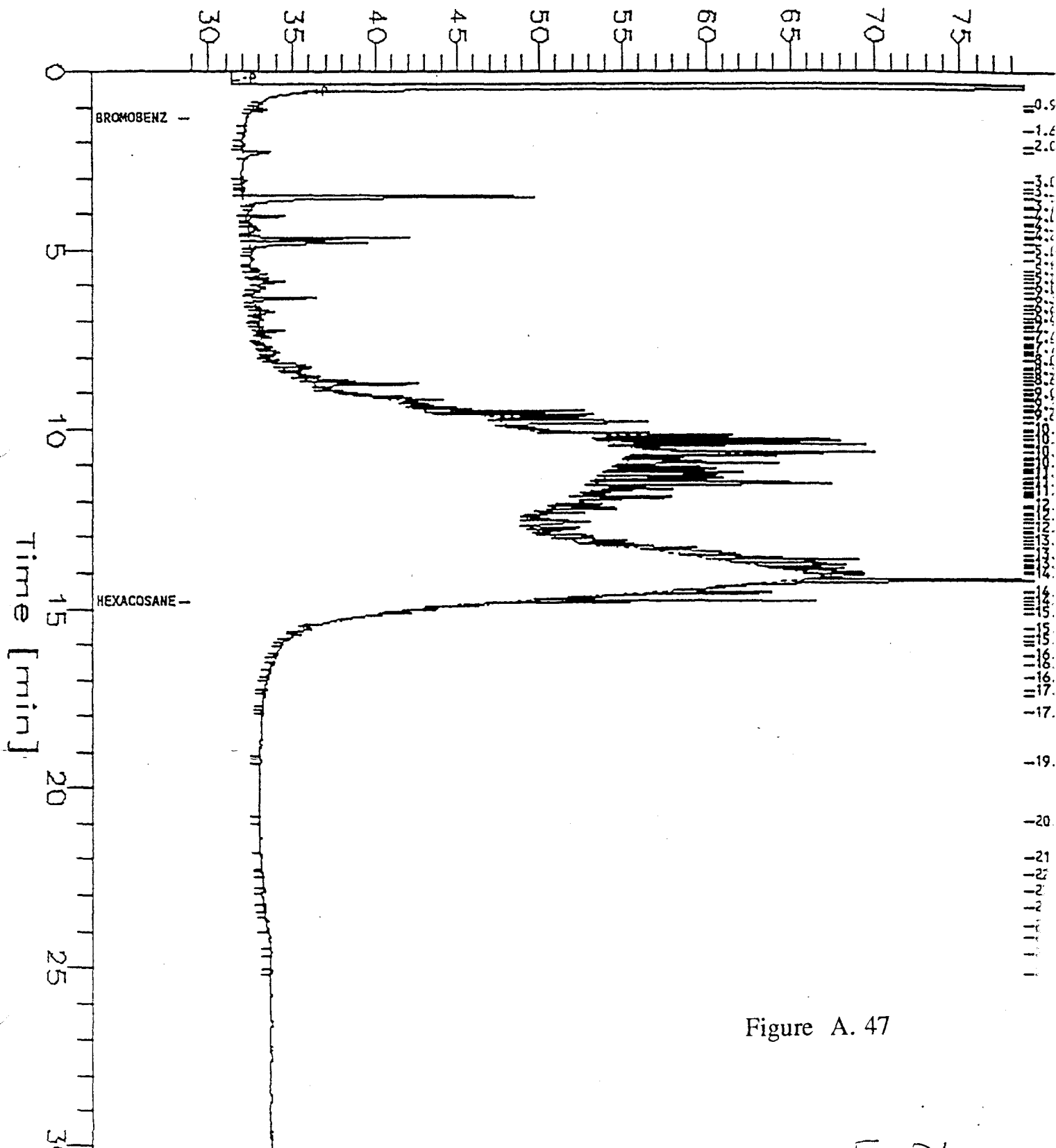


Figure A. 47

JUL 17 '95 14:38 C&T

TEH Chromatogram GC15 CH A

P.29

Sample Name : 121433-032 500:50

Sample #: 21558

Page 1 of 1

Name : g:\gc15\cha\181A092.raw

Date : 7/3/95 4:04 AM

Mod : TEH\_CHA.ins

Time of Injection: 7/3/95 3:30 AM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 28.98 mV

High Point : 78.98 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

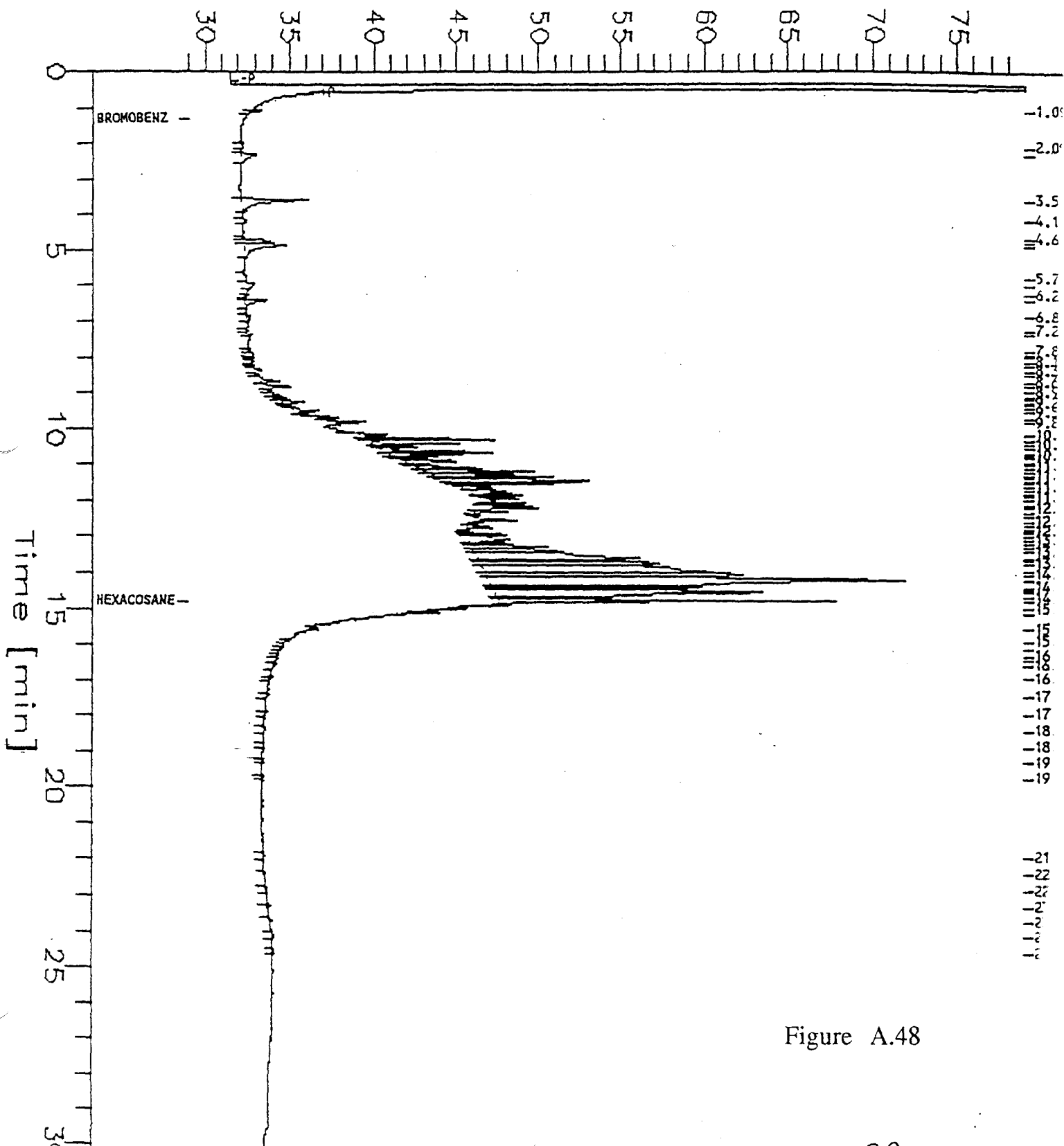


Figure A.48



## TEH Chromatogram GC15 CH A

Sample Name : 121433-033 500:50

Sample #: 21558

Page 1 of 1

eName : g:\gc15\cha\181A089.raw

Date : 7/3/95 1:54 AM

nod : TEH\_CHA.ins

Time of Injection: 7/3/95 1:20 AM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 28.61 mV

High Point : 78.61 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

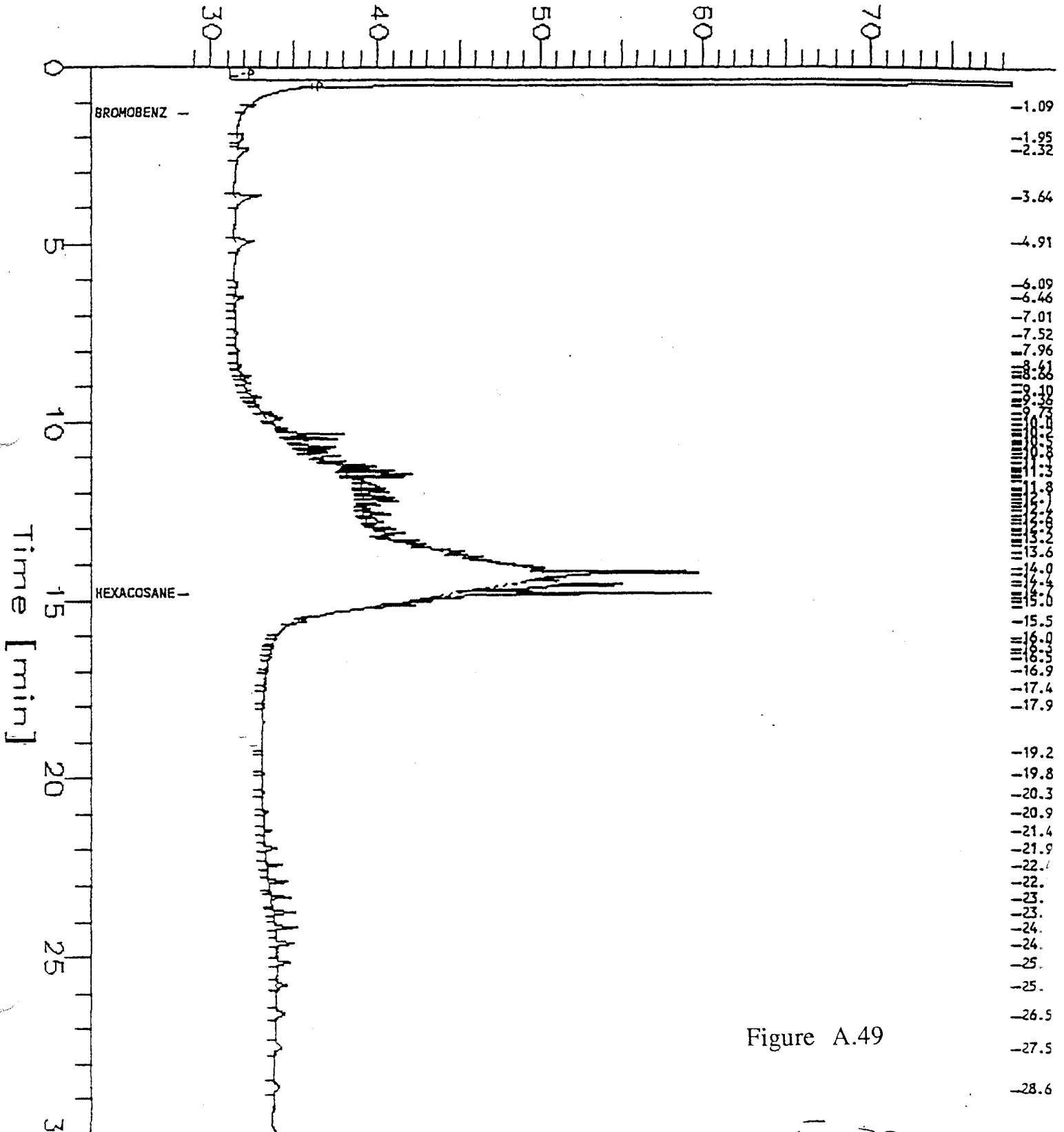


Figure A.49

## TEH Chromatogram GC15 CH A

Sample Name : 121433-034 500:25

Sample #: 21558

Page 1 of 1

eName : g:\gc15\cha\181A082.raw

Date : 7/2/95 8:51 PM

hod : TEH\_CHA.ins

Time of Injection: 7/2/95 8:16 PM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 29.02 mV

High Point : 79.02 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

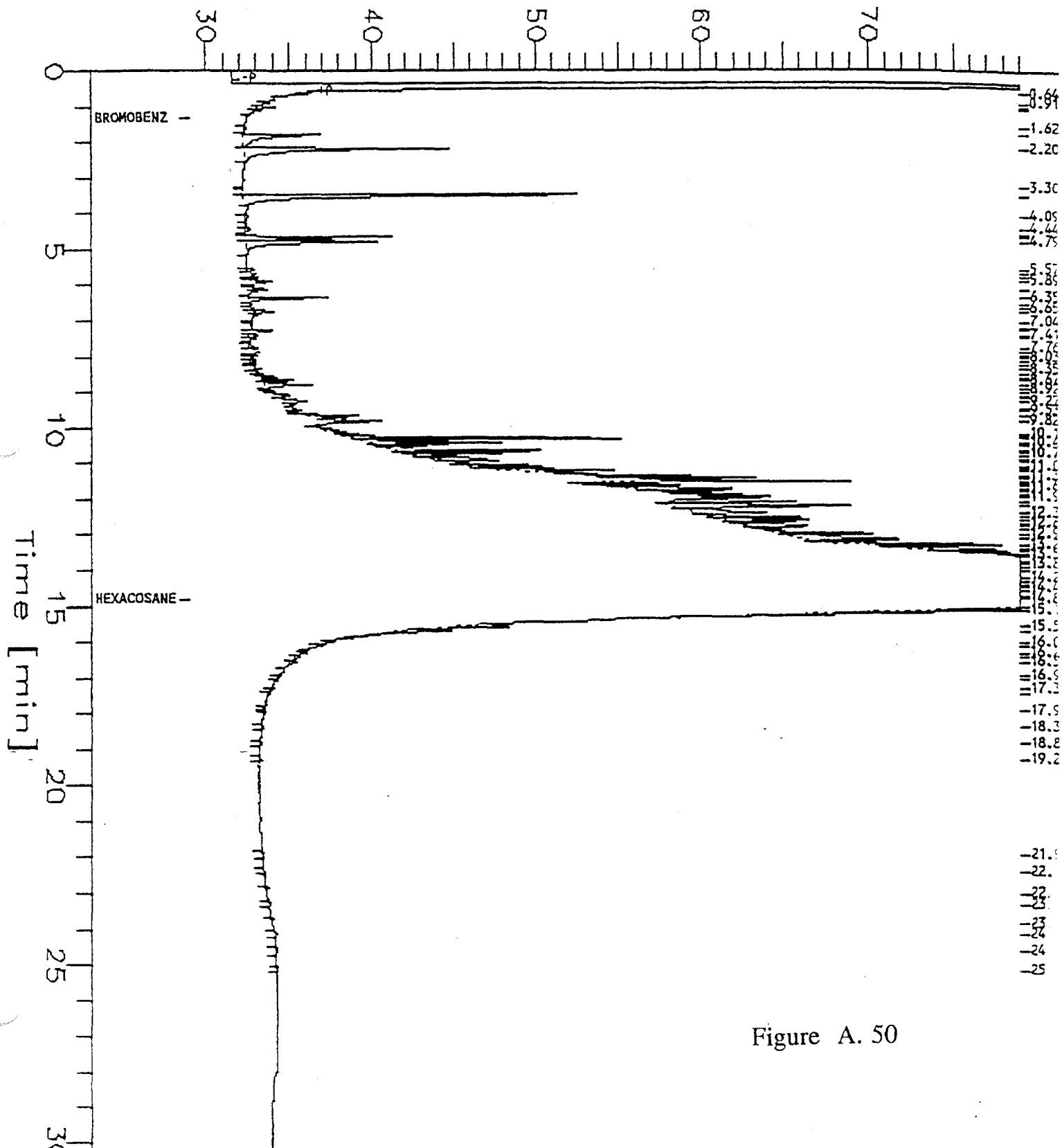


Figure A. 50

Sample Name : 121433-035 500:25

Sample #: 21710

Page 1 of 1

FileName : g:\gc11\cha\188a021.raw

Date : 7/9/95 08:45 AM

Method : GC11DUAL.ins

Time of Injection: 7/9/95 08:13 AM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 27.21 mV

High Point : 77.21 mV

Scale Factor: -1

Plot Offset: 27 mV

Plot Scale: 50 mV

Response [mV]

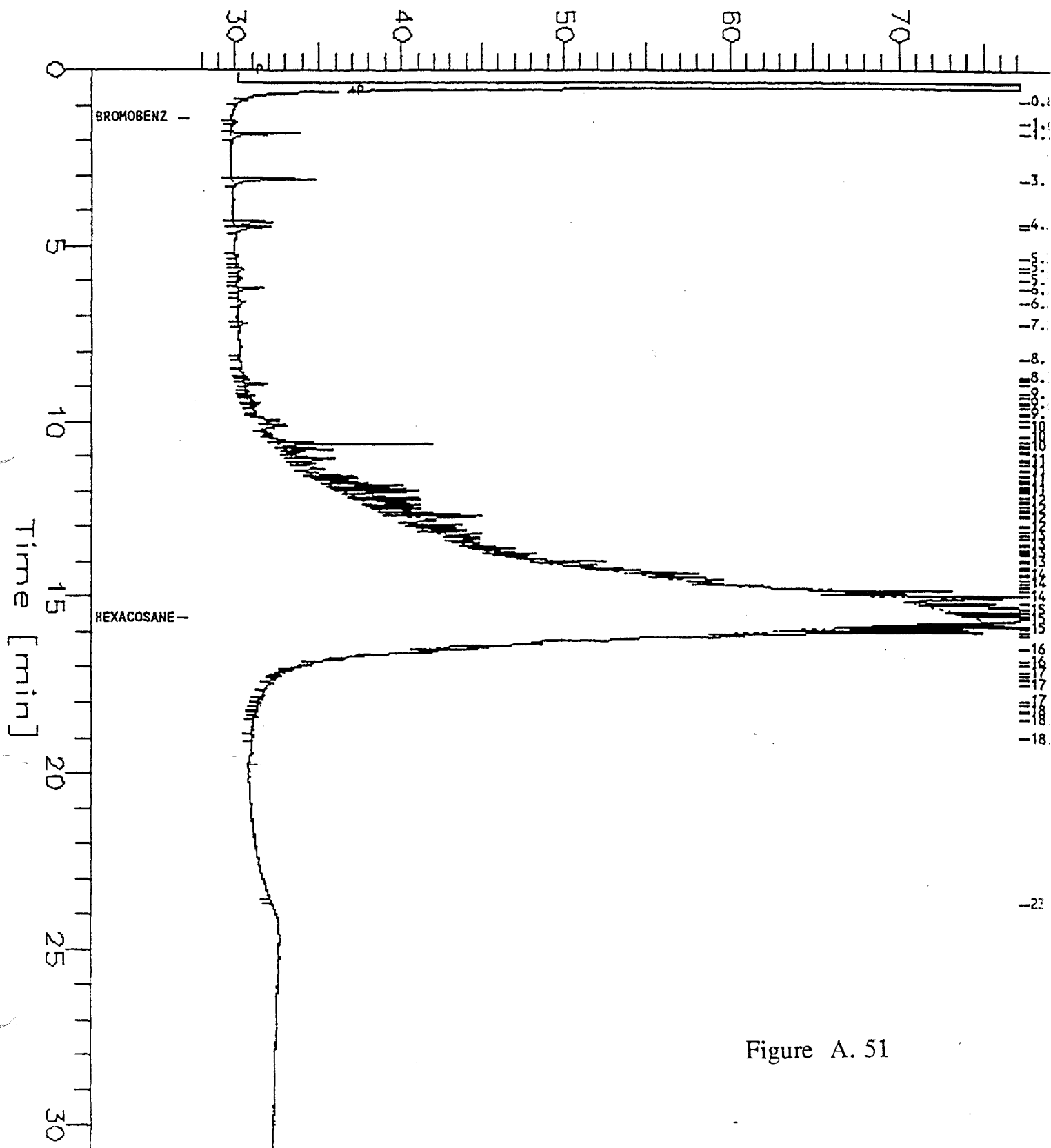


Figure A. 51

## TEH Chromatogram GC11 CH A

Sample Name : 121433-036 500:25  
FileName : g:\gc11\cha\188a022.raw  
Method : GC11DUAL.ins  
Start Time : 0.00 min  
Scale Factor: -1

End Time : 31.92 min  
Plot Offset: 27 mV

Sample #: 21710  
Date : 7/9/95 09:30 AM  
Time of Injection: 7/9/95 08:57 AM  
Low Point : 26.99 mV  
Plot Scale: 50 mV

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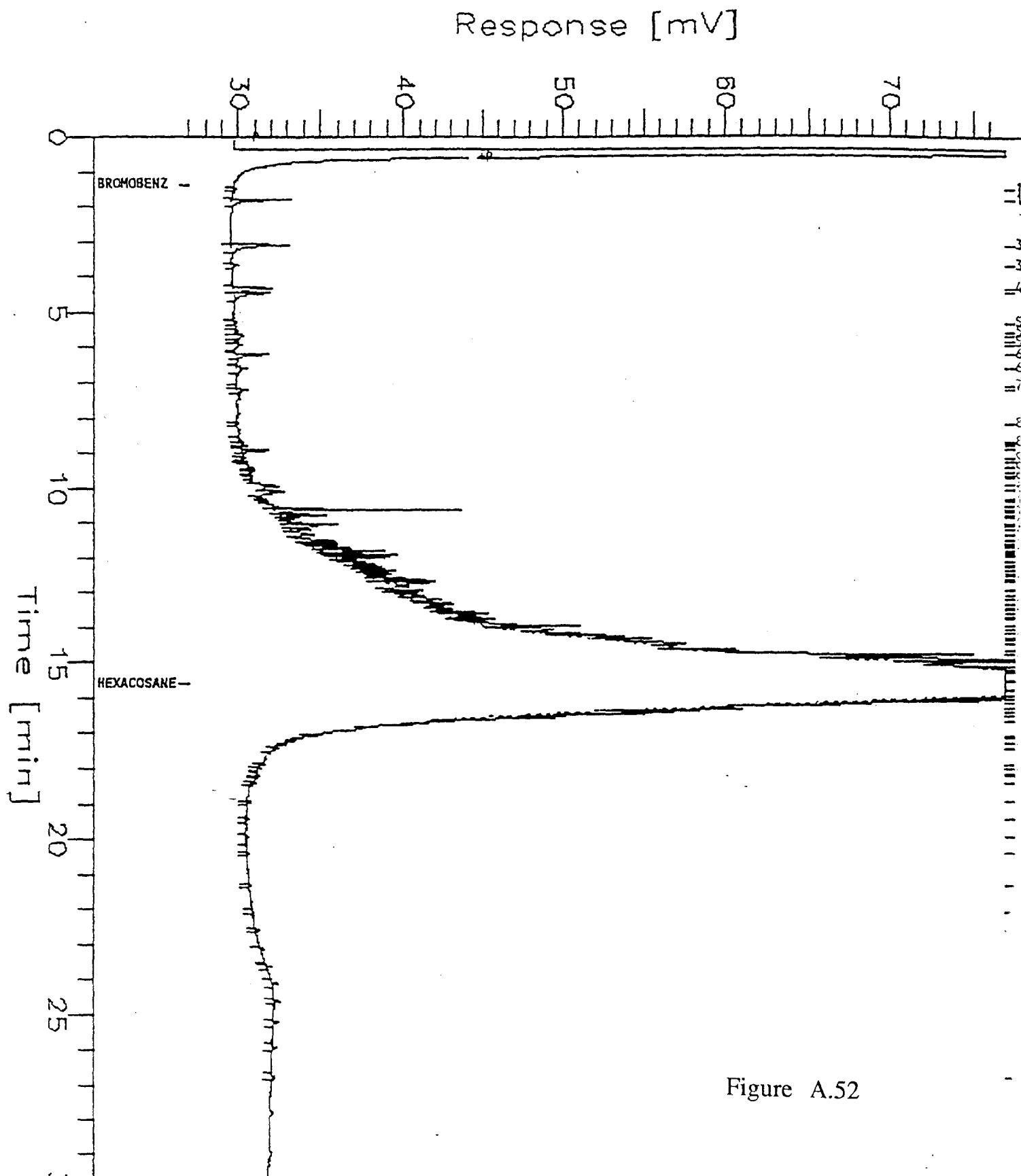


Figure A.52

1501

Sample Name : 121433-037 500:25

FileName : g:\gc11\cha\188a023.raw

Method : GC11DUAL.ins

Start Time : 0.00 min

Scale Factor : -1

End Time : 31.92 min

Plot Offset: 27 mV

Sample #: 21710

Date : 7/9/95 10:14 AM

Time of Injection: 7/9/95 09:41 AM

Low Point : 26.67 mV

Plot Scale: 50 mV

Page 1 of 1

High Point : 76.67 mV

Response [mV]

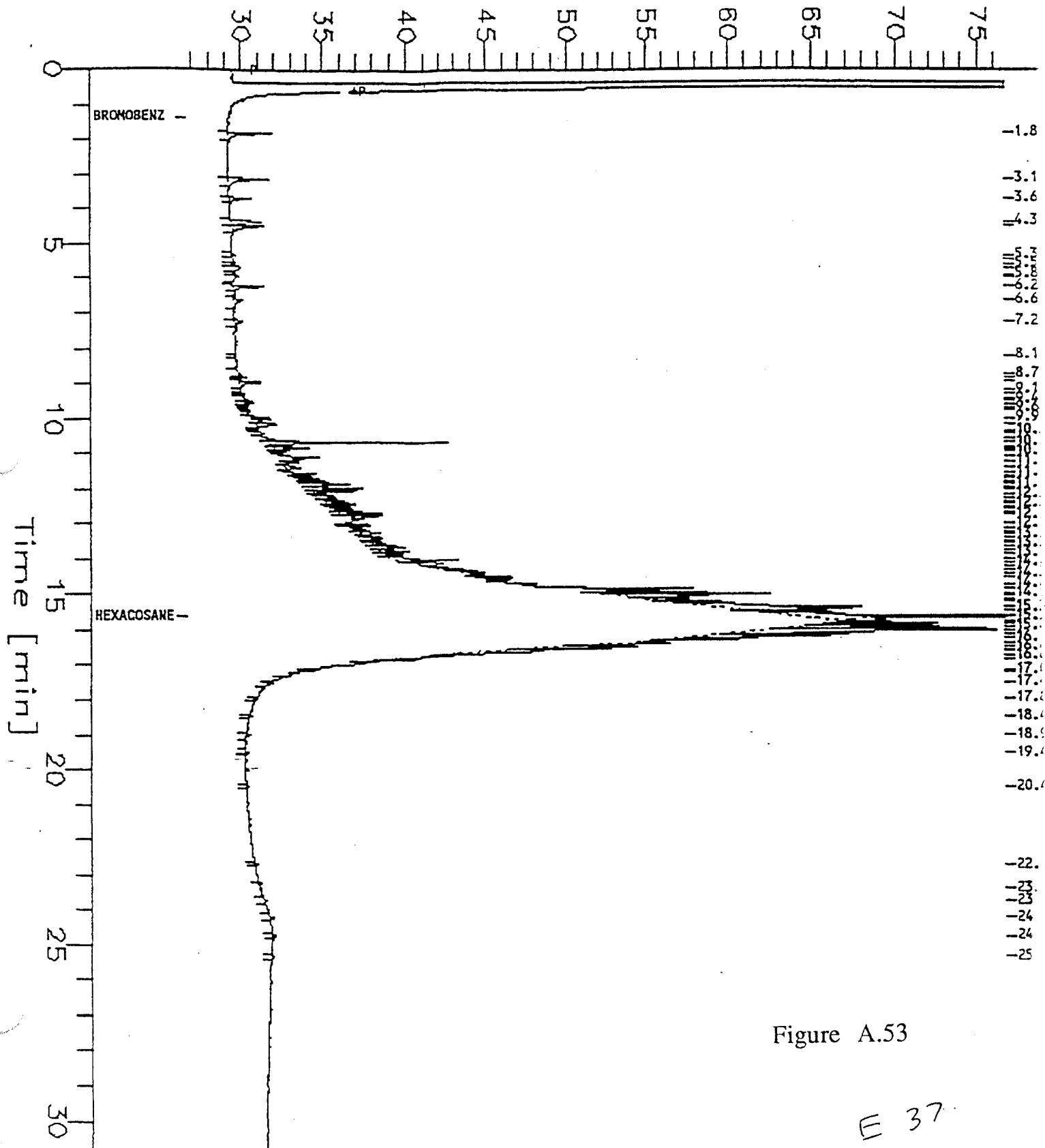


Figure A.53

E 37

Sample Name : 121433-038 500:25

FileName : g:\gc11\cha\188a024.raw

Mod : GC110UAL.ins

Start Time : 0.00 min

Scale Factor: -1

End Time : 31.92 min

Plot Offset: 27 mV

Sample #: 21710

Date : 7/9/95 10:57 AM

Time of Injection: 7/9/95 10:25 AM

Low Point : 26.54 mV

Plot Scale: 50 mV

Page 1 of 1

High Point : 76.54 mV

Response [mV]

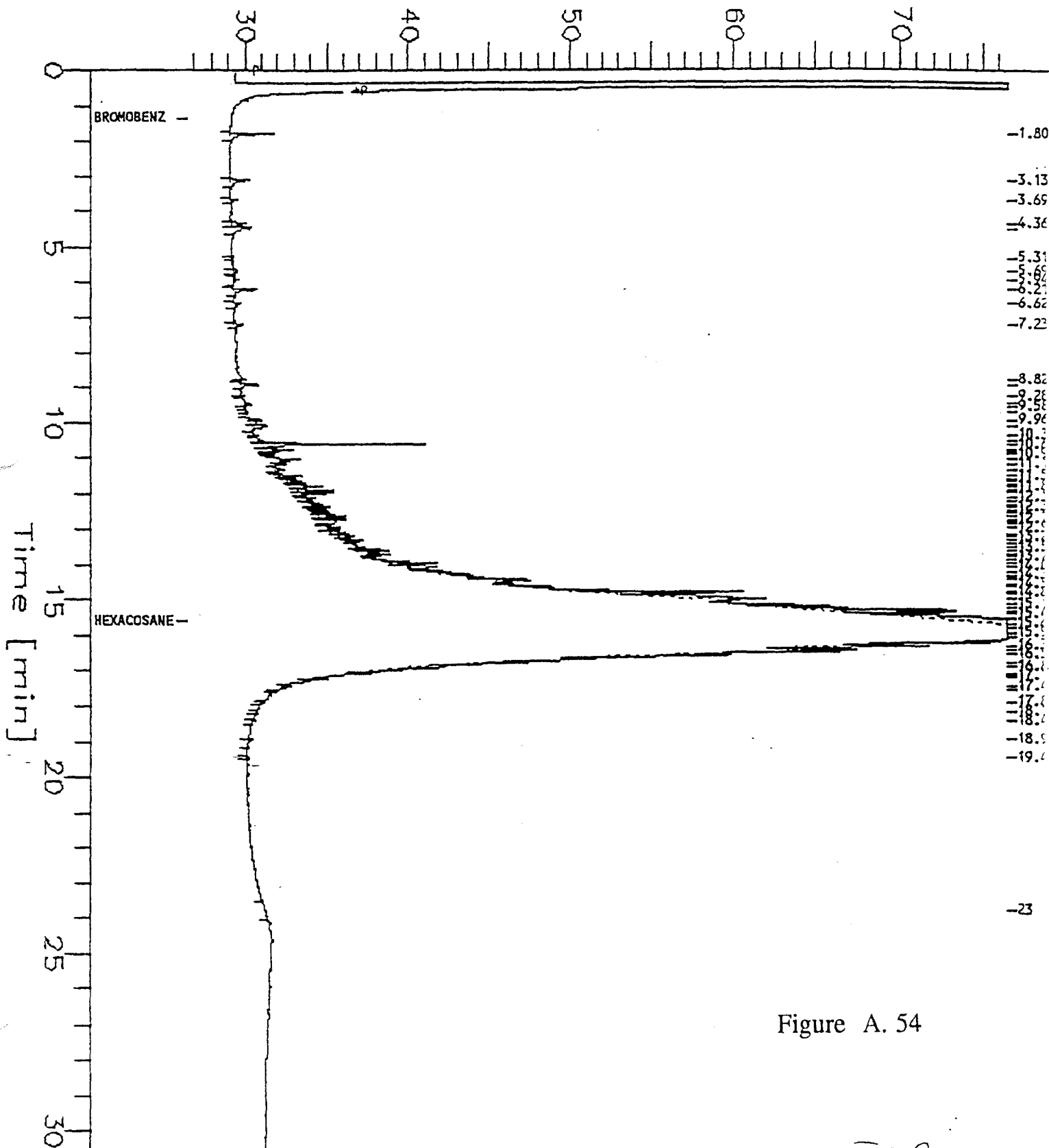


Figure A. 54

Sample Name : 121433-039,500:2.5

FileName : g:\gc11\cha\198a013.raw

Method : GC110UAL.ins

Start Time : 0.00 min

Gain Factor : -1

End Time : 31.92 min

Plot Offset : 29 mV

Sample #: 21610

Date : 7/18/95 10:24 AM

Time of Injection: 7/18/95 09:51 AM

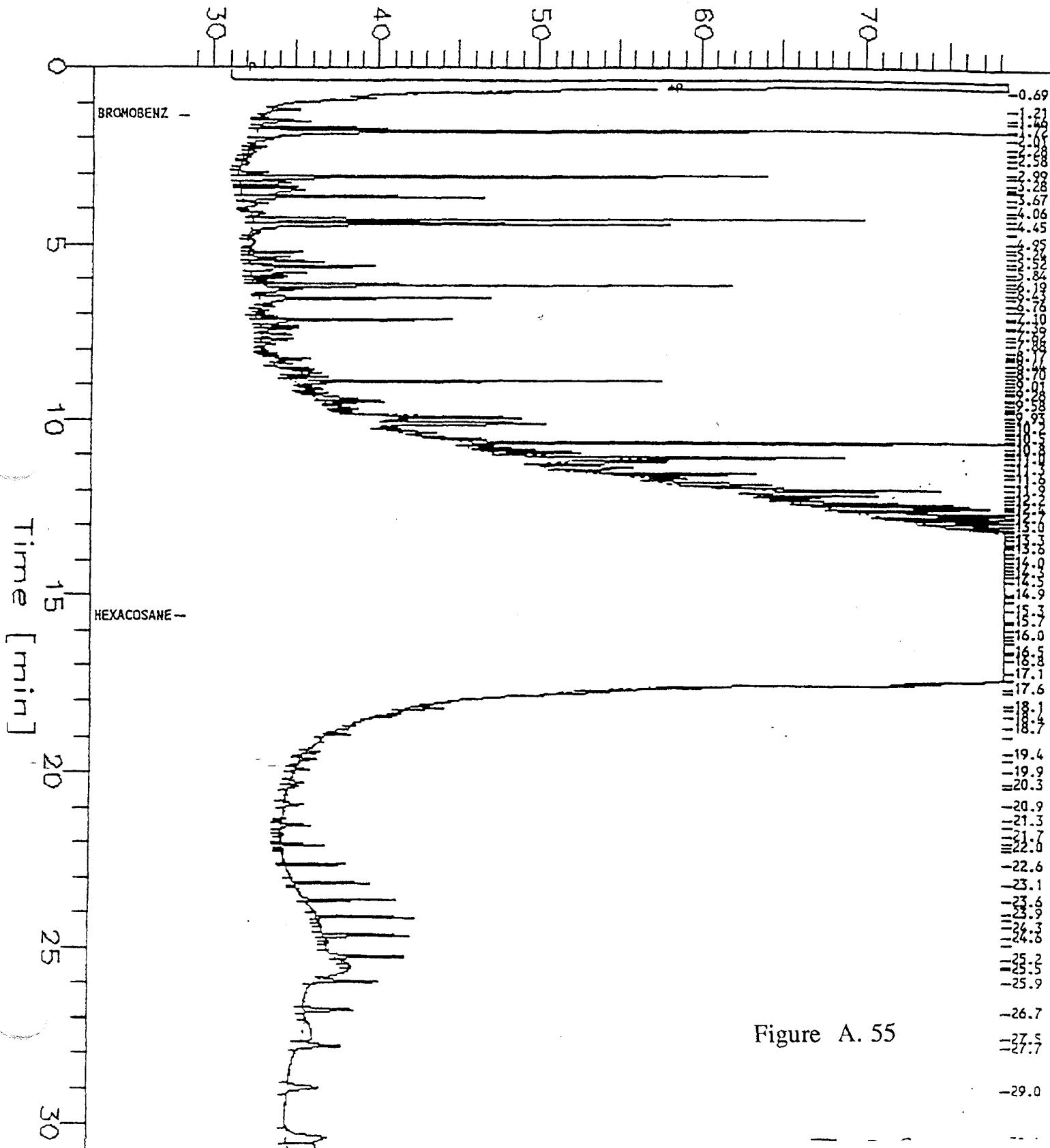
Low Point : 28.47 mV

Plot Scale: 50 mV

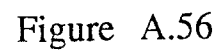
Page 1 of 1

High Point : 78.47 mV

Response [mV]



Sample #: 21710 Page 1 of 1  
Date : 7/9/95 11:41 AM  
Time of Injection: 7/9/95 11:09 AM  
Low Point : 26.44 mV High Point : 76.44 mV  
Plot Scale: 50 mV





Sample Name : 121433-041 500:25

FileName : g:\gc11\cha\188a026.raw

Method : GC11DUAL.ins

Start Time : 0.00 min

Scale Factor : -1

Sample #: 21710

Date : 7/9/95 12:25 PM

Time of Injection: 7/9/95 11:53 AM

Low Point : 26.39 mV

Plot Scale: 50 mV

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End Time : 31.92 min

Plot Offset: 26 mV

High Point : 76.39 mV

Response [mV]

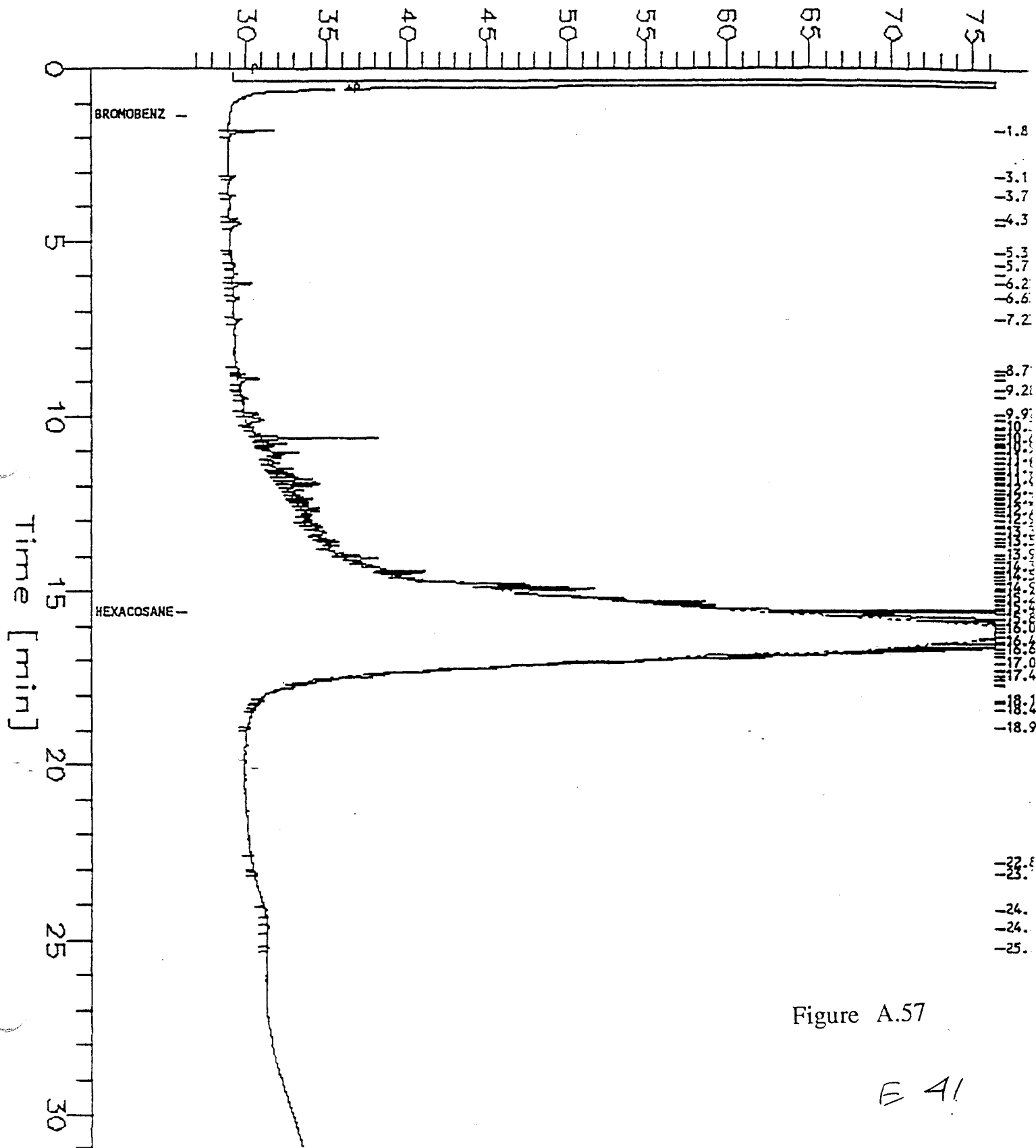


Figure A.57

E 41

## TEH Chromatogram GC11 CH A

File Name : 121433-042,500:25

Name : g:\gc11\cha\198a006.raw

Mod : GC11DUAL.ins

Start Time : 0.00 min

Scale Factor: -1

End Time : 31.92 min

Plot Offset: 29 mV

Sample #: 21610

Date : 7/17/95 11:25 PM

Time of Injection: 7/17/95 10:52 PM

Low Point : 29.02 mV

Plot Scale: 50 mV

Page 1 of 1

High Point : 79.02 mV

Response [mV]

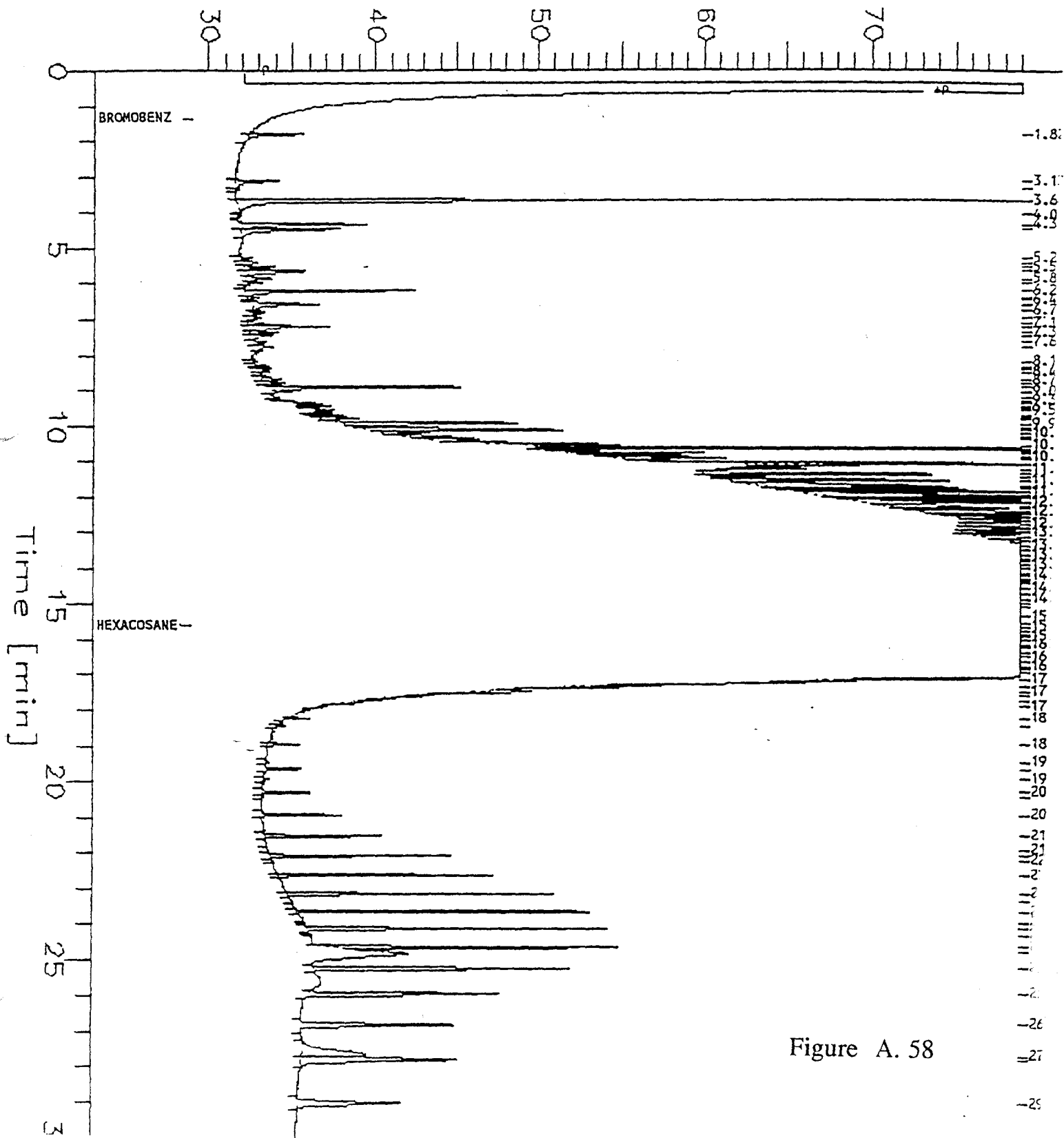


Figure A. 58

## TEH Chromatogram GC15 CH A

Sample Name : 121433-043 370:25

Sample #: 21558

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FileName : g:\gc15\cha\181A083.raw

Date : 7/2/95 9:34 PM

Method : TEH\_CHA.ins

Time of Injection: 7/2/95 9:00 PM

Start Time : 0.00 min

End Time : 31.92 min

Low Point : 28.80 mV

High Point : 78.80 mV

Scale Factor: -1

Plot Offset: 29 mV

Plot Scale: 50 mV

Response [mV]

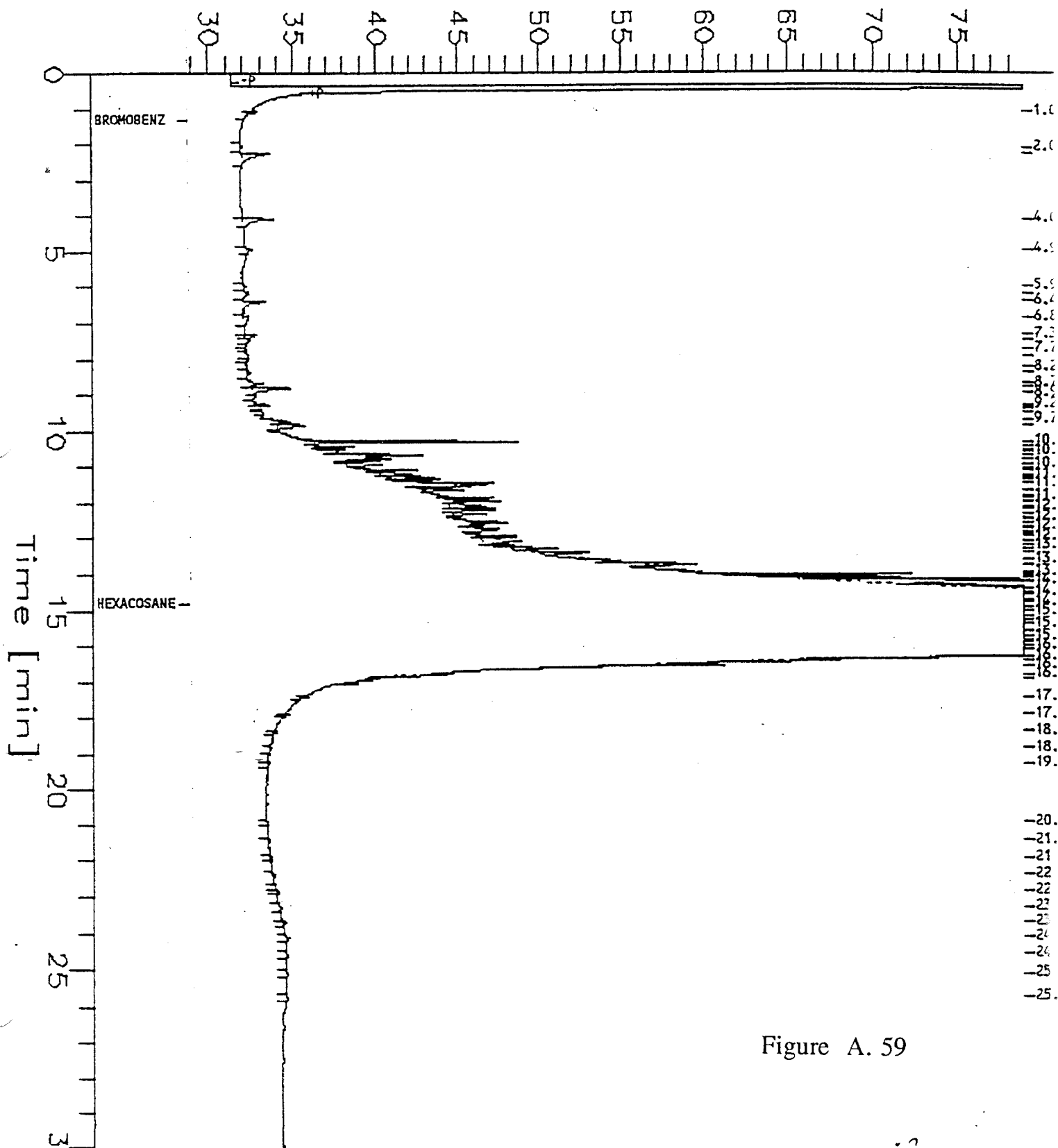


Figure A. 59

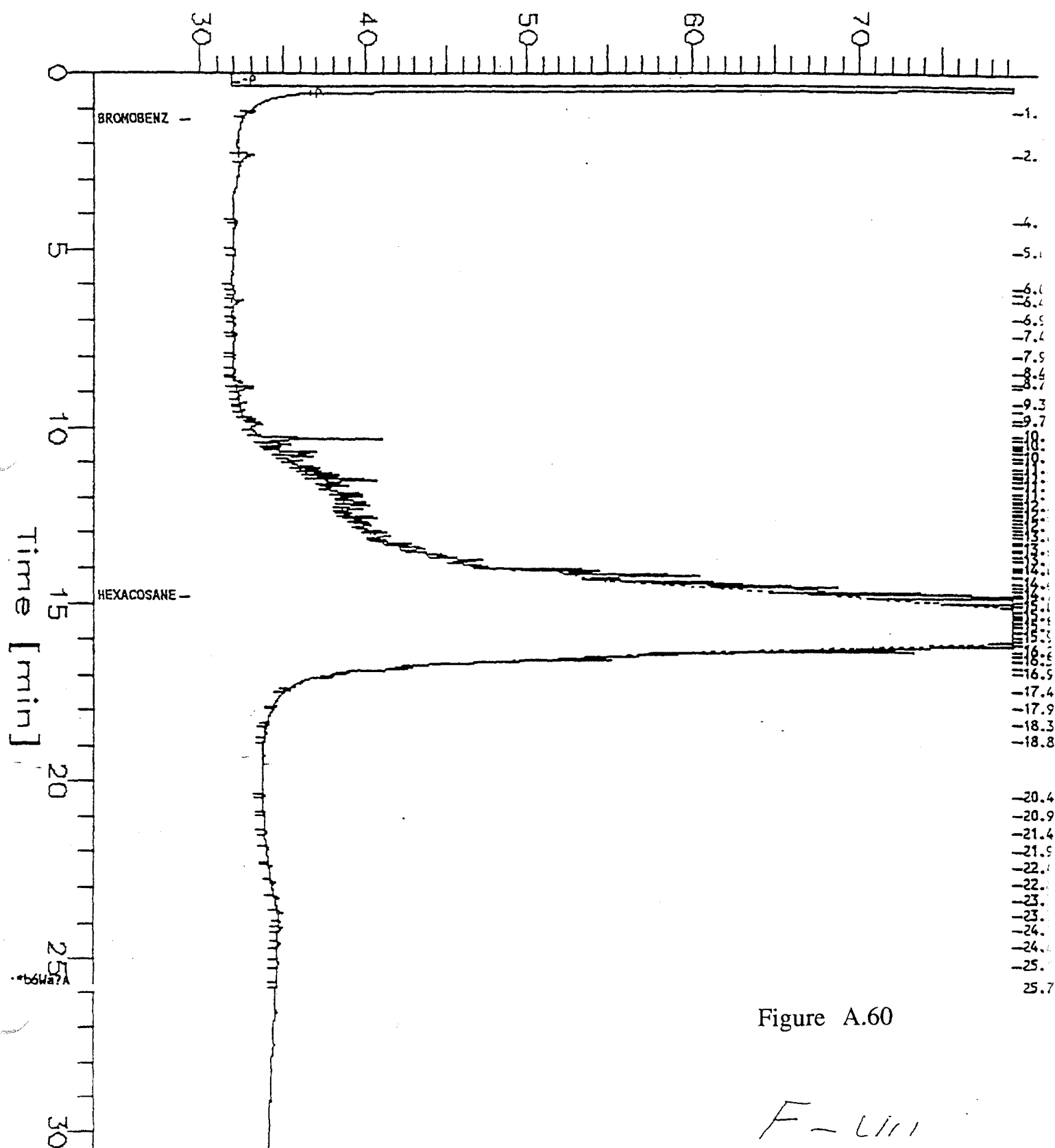


Figure A.60

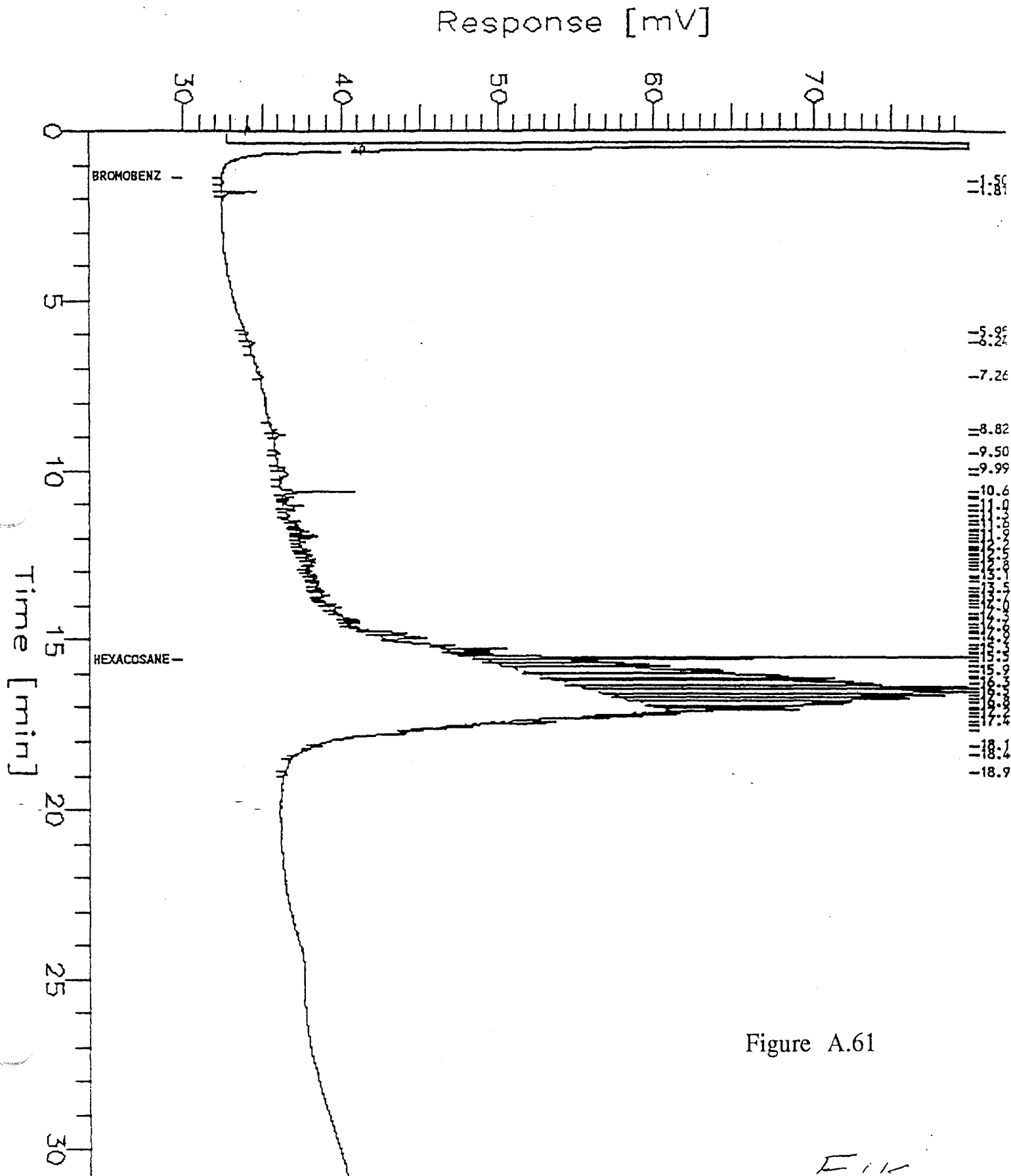
F-Lin

Sample Name : 121433-045 500:25  
 FileName : g:\gc11\cha\188a027.raw  
 Method : GC11DUAL.ins  
 Inj Time : 0.00 min  
 Inj Volume : 1

End Time : 31.92 min  
 Plot Offset: 30 mV

Sample #: 21710  
 Date : 7/9/95 01:09 PM  
 Time of Injection: 7/9/95 12:37 PM  
 Low Point : 29.89 mV  
 High Point : 79.89 mV  
 Plot Scale: 50 mV

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## TEH Chromatogram GC11 CH A

Sample Name : 121433-046 500:25

FileName : g:\gc11\cha\188a028.raw

Method : GC11DUAL.ins

Start Time : 0.00 min

Scale factor: -1

End Time : 31.92 min

Plot Offset: 36 mV

Sample #: 21710

Date : 7/9/95 01:53 PM

Time of Injection: 7/9/95 01:20 PM

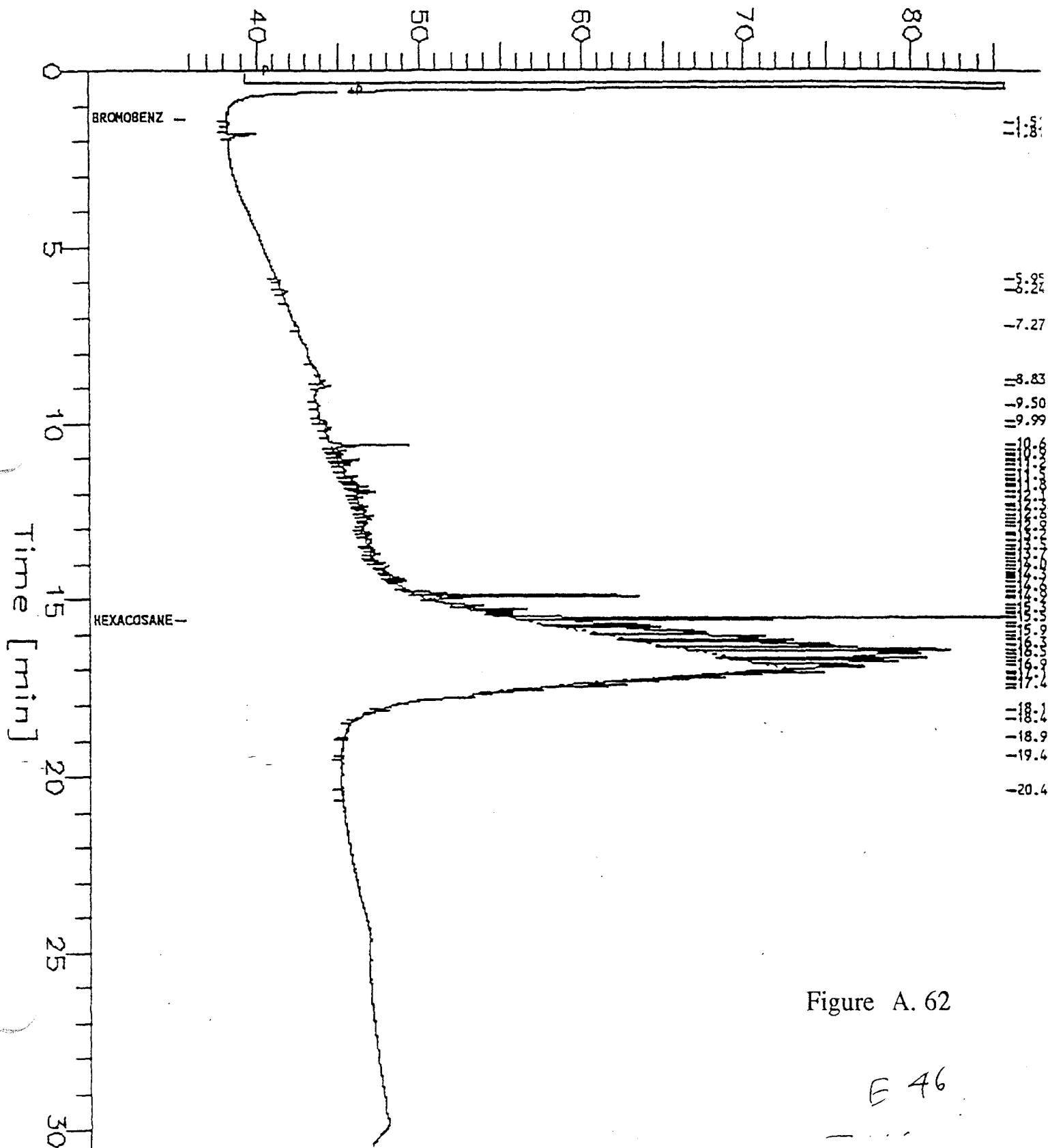
Low Point : 35.65 mV

Plot Scale: 50 mV

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High Point : 85.65 mV

Response [mV]



## TEH Chromatogram GC11 CH A

Sample Name : 121433-047 500:25  
FileName : g:\gc11\cha\188a032.raw  
od : GC11DUAL.ins  
t Time : 0.00 min  
Scale Factor: -1

End Time : 31.92 min  
Plot Offset: 28 mV

Sample #: 21710  
Date : 7/9/95 04:49 PM  
Time of Injection: 7/9/95 04:16 PM  
Low Point : 28.37 mV  
Plot Scale: 50 mV  
High Point : 78.37 mV

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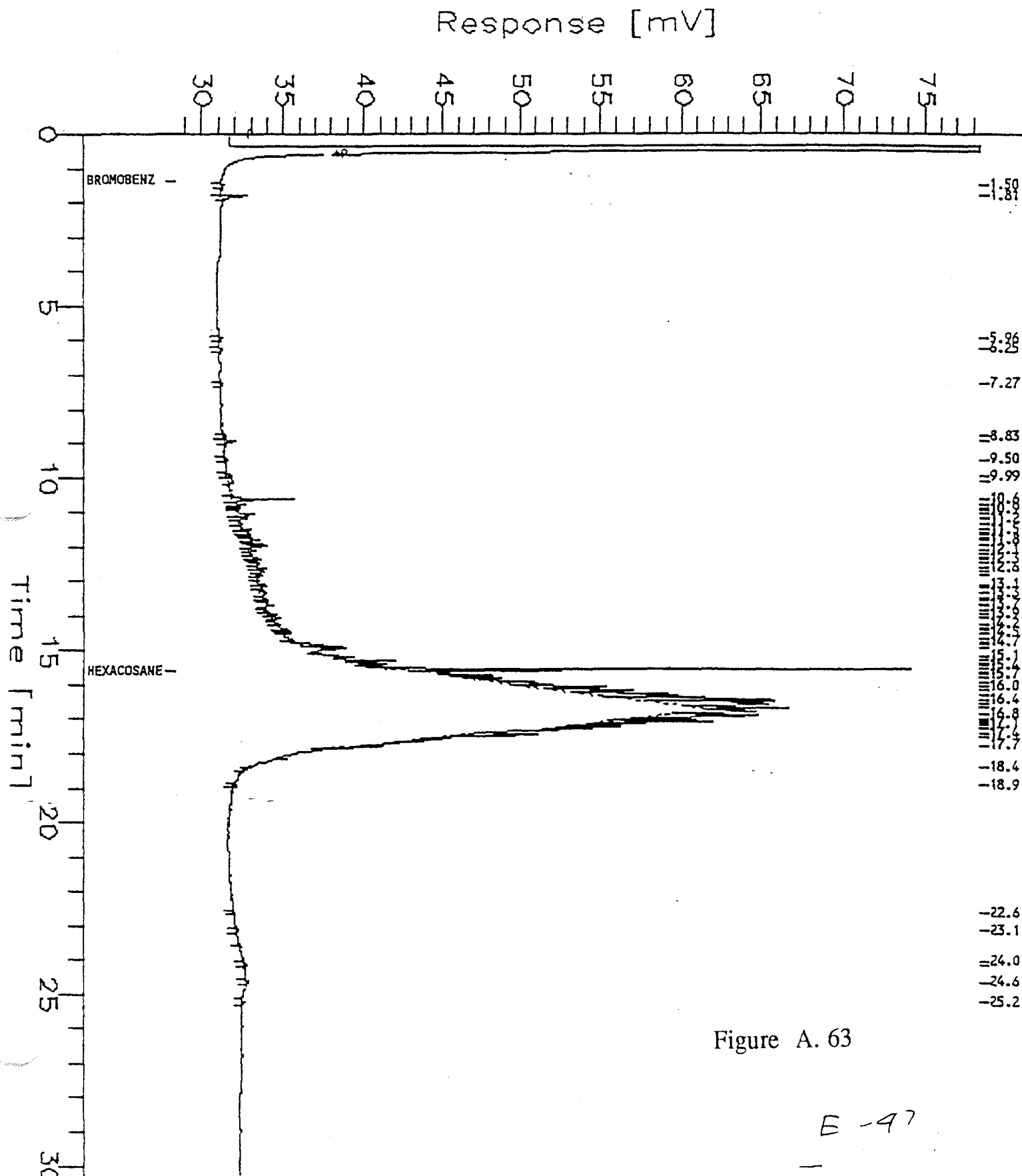


Figure A. 63

E-47

JUL 17 '95 14:52 C&T

Sample Name : 121433-048 500:25

FileName : g:\gc11\cha\188a033.raw

Method : GC11DUAL.ins

Start Time : 0.00 min

Scale Factor : -1

End Time : 31.92 min

Plot Offset: 28 mV

Sample #: 21710

Date : 7/9/95 05:32 PM

Time of Injection: 7/9/95 05:00 PM

Low Point : 27.55 mV

Plot Scale: 50 mV

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P.55

Response [mV]

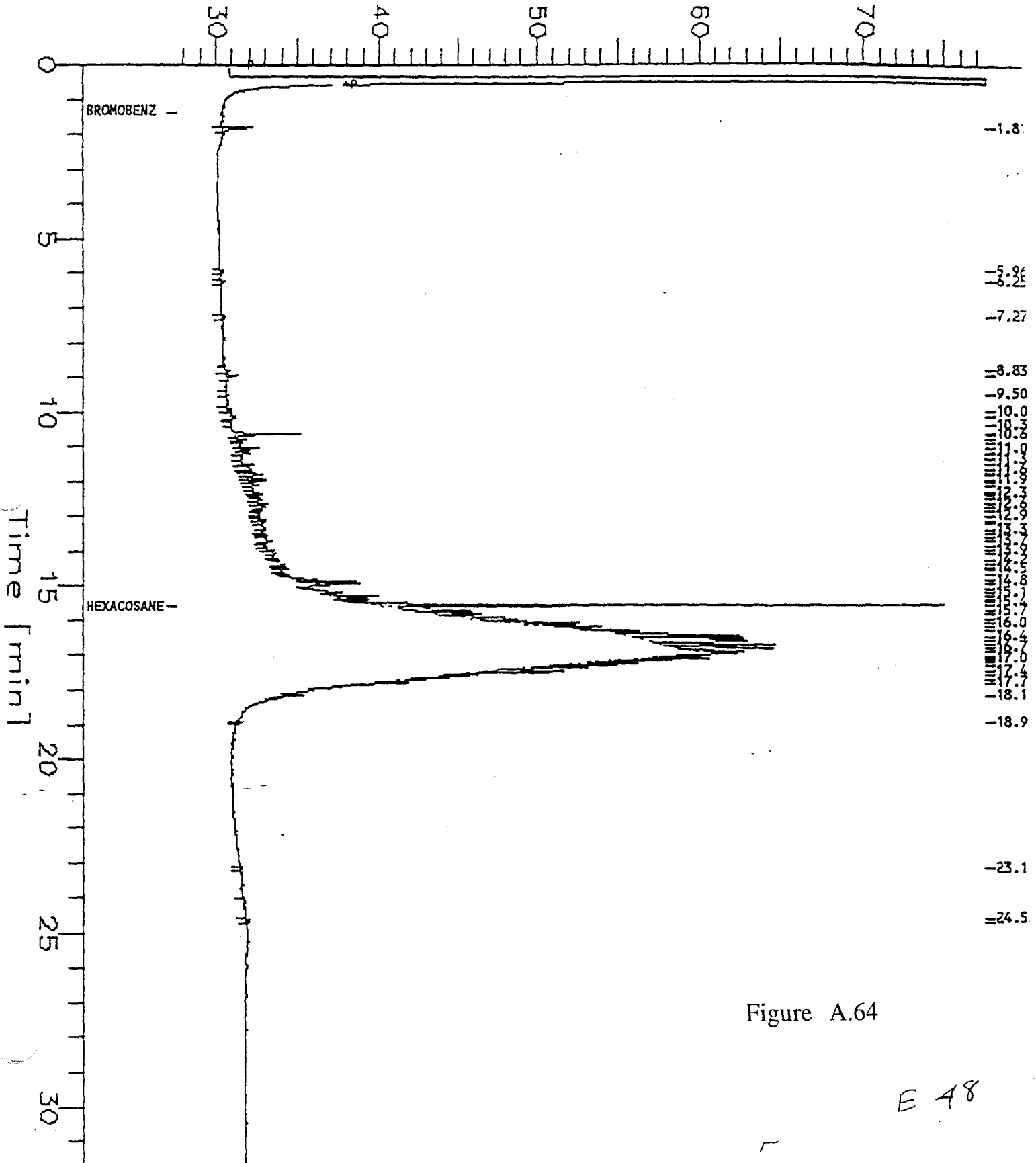


Figure A.64

E 48



Sample Name : 121433-049 430:2.5  
FileName : G:\GC15\CHA\188A054.raw  
Method : TEH\_CHA.ins  
Start Time : 0.00 min  
e Factor : -1

End Time : 31.92 min  
Plot Offset: 30 mV

Sample #: 21683  
Date : 7/18/95 01:48 PM  
Time of Injection: 7/9/95 12:27 AM  
Low Point : 29.92 mV  
Plot Scale: 50 mV  
High Point : 79.92 mV

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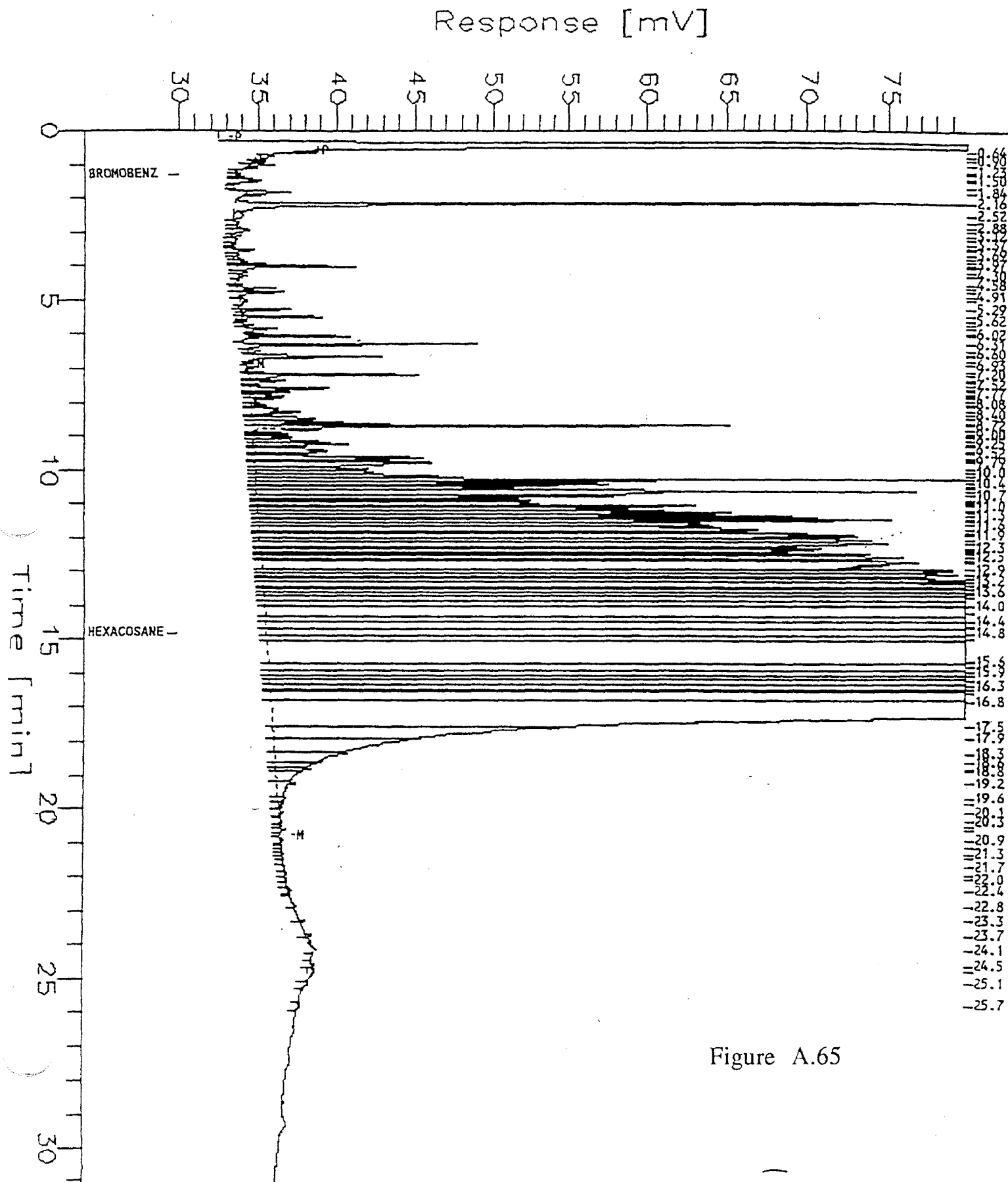


Figure A.65

## APPENDIX A – LABORATORY TREATIBILITY TEST ANALYTICAL RESULTS

### FIGURE A.66

#### PILOT-SCALE TREATIBILITY WORK PLAN

THE ABOVE IDENTIFIED FIGURE IS NOT  
AVAILABLE.

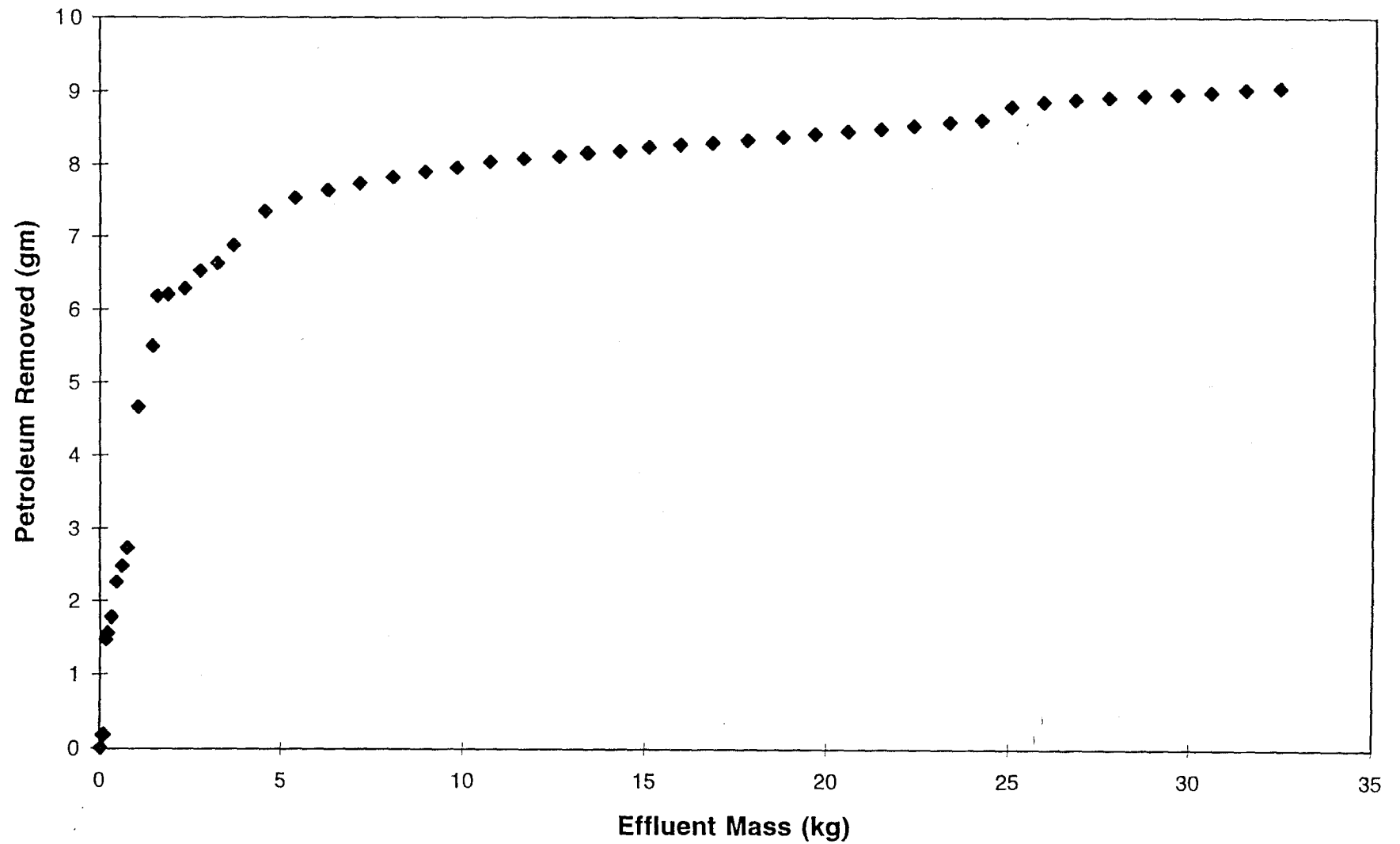
EXTENSIVE RESEARCH WAS PERFORMED BY  
NAVFAC SOUTHWEST TO LOCATE THIS FIGURE.  
THIS PAGE HAS BEEN INSERTED AS A  
PLACEHOLDER AND WILL BE REPLACED  
SHOULD THE MISSING ITEM BE LOCATED.

QUESTIONS MAY BE DIRECTED TO:

**DIANE C. SILVA**  
**RECORDS MANAGEMENT SPECIALIST**  
**NAVAL FACILITIES ENGINEERING COMMAND**  
**SOUTHWEST**  
**1220 PACIFIC HIGHWAY**  
**SAN DIEGO, CA 92132**

**TELEPHONE: (619) 532-3676**

Figure A.67. Petroleum Removed vs Effluent Mass



**Figure A.68: Petroleum Removed vs Pore Volumes Condensed**

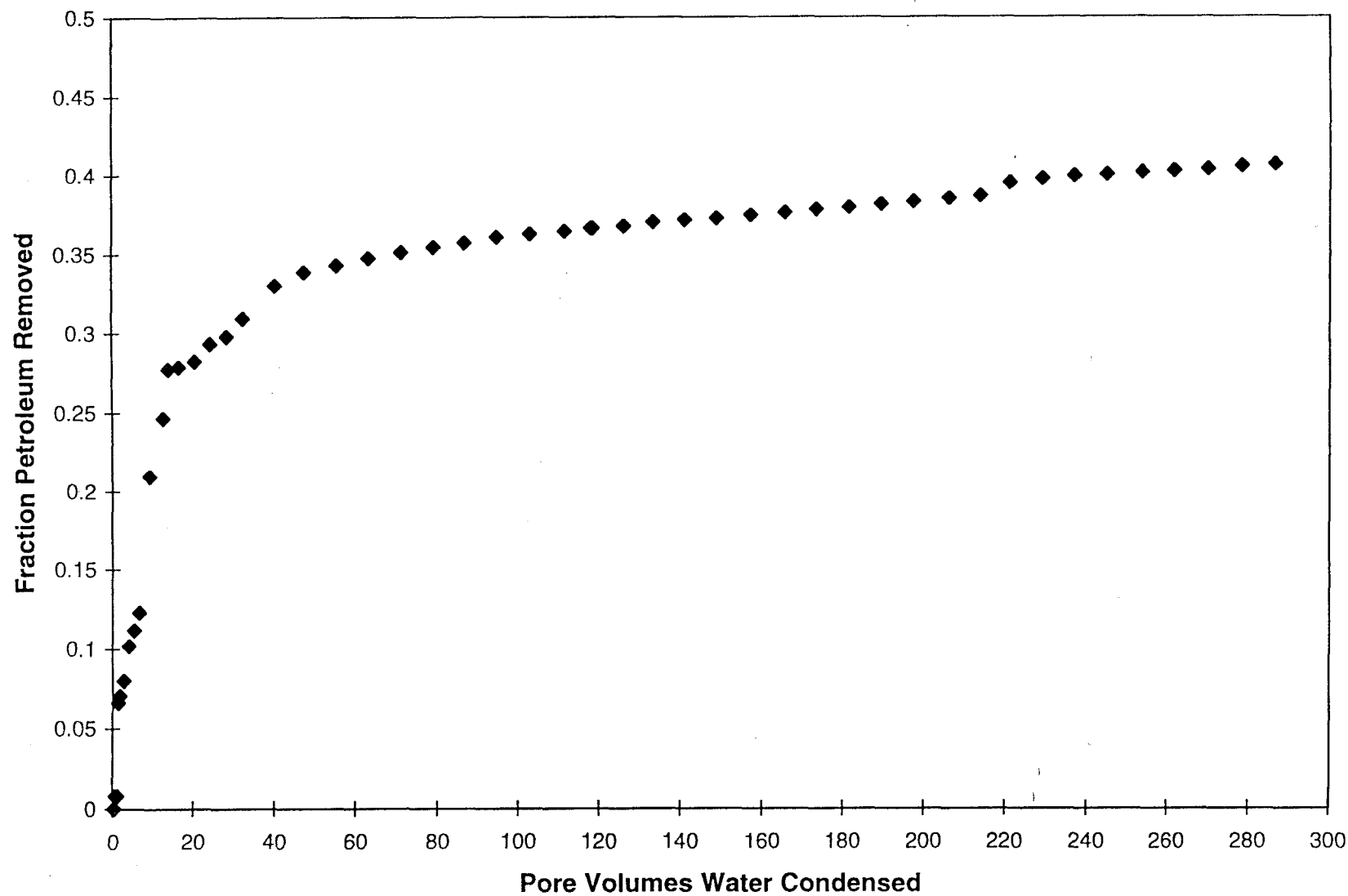
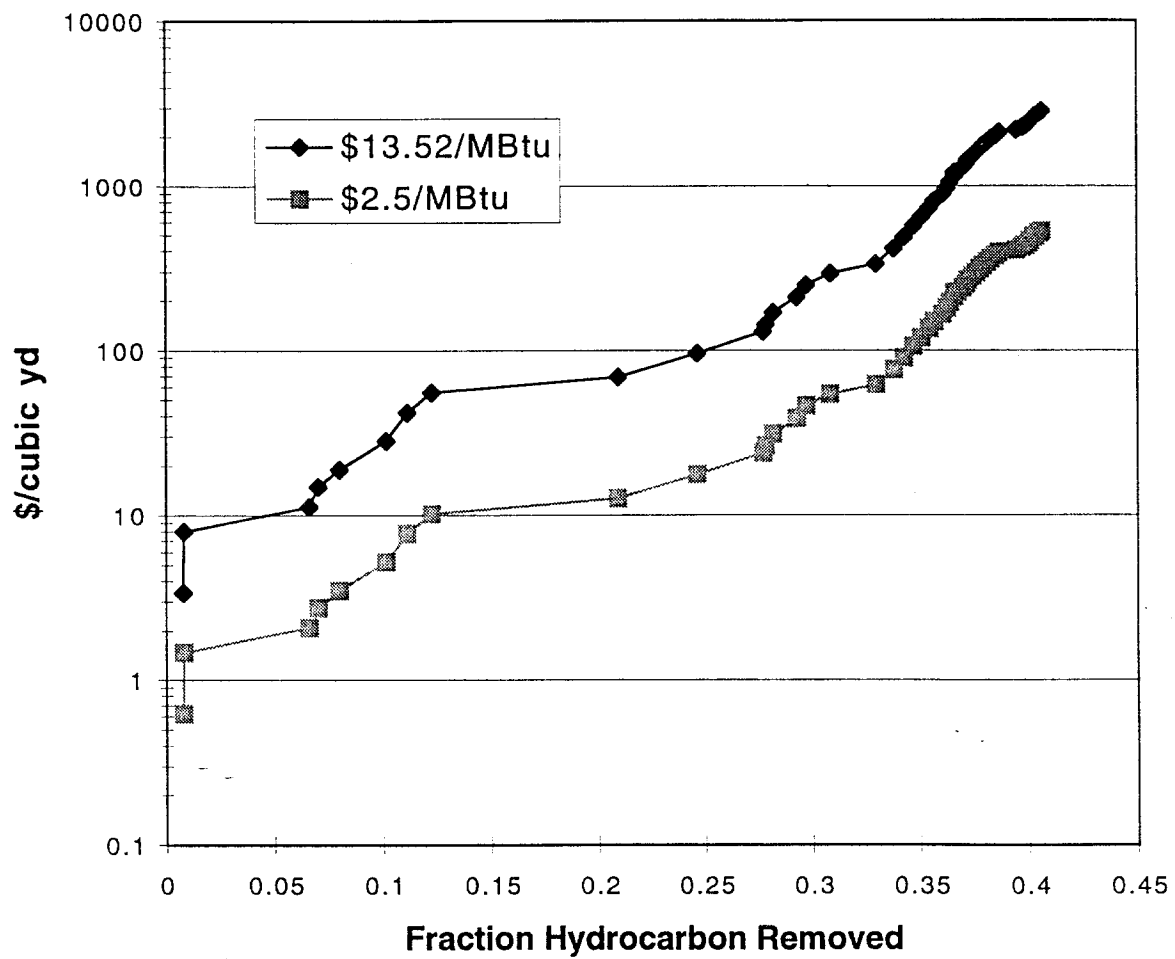


Figure A.69. Cost of Steam vs. Fraction Oil Removed



## **APPENDIX B**

# **CONTRACTOR QUALITY CONTROL PLAN**

**CONTRACTOR QUALITY CONTROL PLAN**

**SITE 13**

**NAVAL AIR STATION, ALAMEDA**

**June 21, 1995**

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2. Organization and Responsibilities
3. Quality Control Management
4. Personnel Training and Qualifications
5. Instructions, Procedures, and Drawings
6. Document Control and Records Management
7. Procurement
8. Data Quality Objectives
  - 8.1 Data Quality Objectives Development Process
  - 8.2 Sampling and Analysis Plan
9. Field Activities
  - 9.1 Site Walk and Permitting
  - 9.2 Sampling Objectives
  - 9.3 Field and Sampling Equipment
  - 9.4 Field Sampling and Well Installation and Soil Sampling By Drilling Rig
  - 9.5 Field Quality Control Samples
  - 9.6 Sample Collection, Preservation, and Holding Times
  - 9.7 Sample Collection Log
  - 9.8 Sample Custody and Documentation Procedures
  - 9.9 Reporting
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11. Report Preparation and Data Reduction/Validation
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## **CONTENTS (Cont)**

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- 22. References  
Attachments

## **1. INTRODUCTION**

This Contractor Quality Control Plan provides project planning for the pilot-scale treatability study at Site 13 Naval Air Station (NAS) Alameda. It includes appropriate procedures necessary to ensure the collection of quality data during the pilot-scale treatability study.

The Contractor Quality Control Program Plan (CQCPP) describes general quality assurance/quality control (QA/QC) procedures to be followed for the partnership agreement between the University of California at Berkeley (UCB) and the U.S. Navy. Standard procedures to be followed for the project are described in the Standard Quality Procedures (SQPs) and the Standard Operating Procedures (SOPs). Copies of the tables of contents for both documents are attached at the end of this appendix.

## **2. ORGANIZATION AND RESPONSIBILITIES**

The project organization for the pilot-scale treatability study is discussed in Section 10 of the Work Plan. Responsibilities for each project position are discussed in Section 2 of the CQCPP. The E2 project organization is shown in Figure B-1, and resumes of the key personnel are attached at the end of this appendix.

## **3. QUALITY CONTROL MANAGEMENT**

Requirements for quality control management are provided in Section 3 of the CQCPP.

## **4. PERSONNEL TRAINING AND QUALIFICATIONS**

Requirements for personnel training and documentation of qualifications are provided in Section 4 of the CQCPP.

## **5. INSTRUCTIONS, PROCEDURES, AND DRAWINGS**

Requirements for instructions, procedures, and drawings are provided in Section 5 of the CQCPP.

## **6. DOCUMENT CONTROL AND RECORDS MANAGEMENT**

Requirements for document control and records management are provided in Section 6 of the CQCPP.

## **7. PROCUREMENT**

Requirements for procurement activities are provided in Section 7 of the CQCPP.

## **8. DATA QUALITY OBJECTIVES**

This section describes the development of environmental investigative activities to assure that data quality objectives (DQOs) are appropriate and consistent with the intended end use of the data.

DQOs have been developed in response to specific technical and planning objectives for Site 13 NAS Alameda. The type and quality of data required to implement investigative or remedial activities will continue to be defined, as necessary. The scope, level of detail, and verification for the design and planning documents will be site-specific.

### **8.1 DATA QUALITY OBJECTIVES DEVELOPMENT PROCESS**

The DQO process will be an iterative process integrated with other project planning operations. The DQO development will consist of a three-phase process consisting of:

- Phase 1: Identification of Project Objectives
- Phase 2: Identification of Data Users/Needs
- Phase 3: Design of Data Collection Program

The DQO process is intended to assure that data collected are sufficient, appropriate, and of adequate quality for their intended use. In the event the evaluation of the data indicates that the information collected is insufficient to meet the project objectives, the DQO process shall be reimplemented and refined so that future sampling and analyses will provide the requisite support to meet the project objectives. Such reimplementation and refinement is considered a normal part of the development process. The complexity of the site and the initial information available will determine the number of times the DQO process is reimplemented/refined.

The development and documentation of the DQO process is the responsibility of the Project Manager, Contractor Quality Control (CQC) Manager, and technical personnel; this is one of the first actions taken for the pilot-scale treatability study.

### **8.1.1 Phase 1 - Identification Of Project Objectives**

During Phase 1, the project objectives are defined and clarified with the Navy and information is collected to determine the following:

- presence or absence of contamination;
- types of contaminants;
- concentrations and distribution of contaminants;
- contaminant release mechanisms;
- contaminant transport pathways;
- boundaries of sources and pathways;
- environmental/public health concerns; and
- potential remedial solutions.

This information has been collected and is presented in the Work Plan at a level of detail sufficient for a pilot-scale study.

The Project Manager is the designated decision maker during the DQO process. In this role, he/she is responsible for coordinating among and between the Navy, UCB, government officials, technical personnel, subcontractors, and other parties who may be affected by or involved with site activities and conditions.

The Project Manager also identifies the appropriate technical staff for the project to gather all necessary information for the pilot-scale treatability study, including results of previous investigations, reports, records of permits, releases and disposal, manufacturing or disclosure information, as well as maps and field notes. This information collection and review is performed to determine whether the quality and quantity of available information is sufficient and comprehensive enough to support the development of the pilot-scale treatability study. Missing information is identified and information requirements are established in Phase 2.

The Project Manager is responsible for determining whether project activities are proceeding on-track and are consistent with established sampling strategies and regulatory requirements.

### **8.1.2 Phase 2 - Identification Of Data Users/Needs**

The DQO process implemented during Phase 2 defines data users and the types of data needed to fill any data insufficiencies identified during Phase 1. A list of actions that address the needs of the environmental data collection activities is developed and, at a minimum, includes the following:

- (a) Identify data uses – Data for the pilot-scale treatability study include additional site characterization, monitoring during implementation of the pilot-scale treatability study, and post-operation site characterization.
- (b) Identify data types – The data types to be obtained are identified in Section 6 of the Work Plan.
- (c) Identify data quality levels – The required data quality levels for the project are Level I and Level III. A description of each level is as follows:

Level I: Field screening or analysis using portable instruments. Results are often not compound-specific and not quantitative, but results are real-time. This screening will be performed for health and safety purposes as described in the Site Health and Safety Plan (SHSP) and for monitoring purge water during groundwater monitoring well development and groundwater sampling.

Level III: All analyses performed in an off-site laboratory. For this project, Level III analyses will not use Contract Laboratory Protocol (CLP) procedures.

- (d) Identify data quantity needs – Estimates of the number of samples required to meet the objectives of each sampling activity during the pilot-scale treatability study are presented in Section 9.3 of the Work Plan.
- (e) Evaluate sampling/analysis options. The sampling and analysis plan is presented in the Work Plan.

### **8.1.3 Phase 3 - Design Of Data Collection Program**

The data collection program for the pilot-scale treatability study is presented in the sampling and analysis plan, Section 9.3 of the Work Plan. ARARs are not provided because this is not a full-scale remediation process.

## **8.2 SAMPLING AND ANALYSIS PLAN**

The Site 13 sampling and analysis plan includes the data collection requirements and describes the objectives of the sampling efforts, ultimate use of the data, data quality requirements, sampling protocols and procedures, types, locations, frequency of sample collection, and reporting requirements.

## **9. FIELD ACTIVITIES**

Operations to be conducted during the implementation of the pilot-scale treatability study include:

- Additional site characterization for locating injection/extraction wells. This will include cone penetrometer testing and laser-induced fluorescence.
- A survey of the site to determine ground elevations and reference-existing wells and prior soil borings.
- Grading of the site to prepare drawings from surface covering system.
- Installation and development of injection/extraction wells with associated soil and groundwater sampling; water and product level measurements; and steam and hydraulic testing.
- Installation of temperature monitoring wells.
- Installation of surface electrode and electrode wells.
- Installation of surface containment system.
- Construction of the treatment system and hook-up to the injection/extraction wells.
- Conducting water influent and effluent sampling.
- Obtaining temperature, electrical resistivity, and flow rate measurements.
- Waste sampling (soil, water, free product).
- Preparation of 100% design for the expansion to full pilot scale.

- Preparation of a final report on the performance of the pilot-scale treatability test.
- Preparation of 75% designs for full-scale surface coverings and wells.

Further descriptions of each of these tasks are provided in the Work Plan.

## **9.1 SITE WALK AND PERMITTING**

Before initiation of any field activities, the project superintendent will review available maps, plans, and drawings to identify potential buried, surface, or overhead hazards in the area planned for the pilot-scale treatability system. Site access and security requirements will be determined as required. The objectives of the site walk will be to:

- Evaluate site safety considerations (utility locations, health and safety concerns).
- Identify boring and well locations and available access.
- Identify the locations of areas to store equipment to be used during the project.
- Identify the location of areas to be used to store drill cuttings, water, and other wastes pending disposal.
- Discuss the field activity sequence and schedule as they relate to security needs, NAS Alameda operations, project operations, and subcontractor access requirements.
- Obtain necessary permits or approval of state, county, or NAS Alameda authorities.

## **9.2 SAMPLING OBJECTIVES**

Representative samples will be collected during the pilot-scale treatability study in order to ascertain the viability of the Steam Enhanced Extraction (SEE) process as a cost-effective *in situ* remedial method for remediation of hydrocarbon contaminated soils. The representativeness of each sample will be ensured by reducing potential sources of contamination or bias that may be introduced by sampling equipment, ambient conditions, handling, and/or sample preservation techniques. Field personnel responsible for collecting samples during field activities at Site 13 will follow prescribed protocols and the requirements of the

SOP, SQP, and sampling and analysis plan presented in Section 9.3 of the Work Plan while collecting samples.

### **9.3 FIELD AND SAMPLING EQUIPMENT**

Several different pieces of equipment and field supplies will be used to support the pilot-scale treatability study. Required equipment includes but is not limited to:

- Heavy equipment for grading the site
- Drilling equipment
- Sampling equipment (i.e., split barrel, pumps, bailers)
- Sampling containers (i.e., brass sleeves, VOAs)
- Decontamination supplies
- Waste storage containers (i.e., Baker tanks, drums)
- Field screening equipment (i.e., PID, pH meters)
- Personal protective equipment.

The sampling equipment selected for use during the pilot-scale treatability study will be constructed of materials that will not react with or contaminate the samples collected through its use. Unless otherwise specified, the sample containers used will be precleaned according to EPA protocols. In order to minimize the decontamination of sampling equipment, where permitted, sampling equipment made of disposable materials may be used and discarded following its use.

Decontamination of all reusable sampling equipment used during this project will be performed initial use on-site and between each use at distinct sample locations. Sample equipment decontamination procedures are described in the sampling and analysis plan of the Work Plan and SOPs.

### **9.4 FIELD SAMPLING AND WELL INSTALLATION METHODS**

Field sampling and well installation methods are presented in Section 9.3 of the Work Plan.

### **9.5 QUALITY CONTROL SAMPLES**

QA/QC samples will be collected and analyzed throughout the field and laboratory phases of this project. QA/QC samples collected in the field will include duplicates, equipment rinseate blanks, and trip blanks. QA/QC samples analyzed by the contract laboratory will consist of duplicates, matrix spikes, matrix spike duplicates, and method blanks. QA/QC samples will be taken in accordance with



the SOP 18.1. The description of these samples follow and the anticipated number of each field QA/QC samples type is specified in Section 9.3 of the Work Plan.

- Rinseate Blank – Samples consisting of ASTM Type 2 reagent water collected from a final rinse of sampling equipment after the decontamination procedure has been performed. One equipment rinseate will be collected per week of sampling and analyzed for the same parameters as the samples being collected for the treatability study; equipment rinseate samples will be collected from the cleaned brass sample used for soil liner sampling and the disposable polyethylene bailers used for groundwater sampling. Equipment rinseate samples will not be required during collection of operational monitoring samples because the samples will be collected directly into the sample containers.
- Trip Blank – Samples consisting of a pair of "clean" volatile organic analysis (VOA) vials filled with ASTM Type 2 water. These vials are prepared by the laboratory, travel to the field site, and are returned to the laboratory for storage and analysis along with the field samples. The trip blank data will demonstrate whether the samples were exposed to contamination during storage and transport to the laboratory. Trip blanks will be analyzed for VOA; therefore, the containers must not contain any head space. One trip blank per week of sampling will be prepared and analyzed for BTEX. One trip blank will also accompany each shipment of operational monitoring samples. Matrix spike/matrix spike duplicates samples measure the accuracy and precision of the analytical methods.
- Replicate Samples (Field Duplicate, Matrix Spike, Matrix Spike Duplicate) – Field duplicate samples provide data to assess the precision of the sampling methods. Duplicates of soil samples will not be collected. Field duplicates of groundwater samples will be collected at a minimum frequency of 10% of the samples collected and analyzed for the same parameters as the groundwater samples. Duplicate samples will not be collected during collection of operational monitoring samples.
- Split Samples – No split samples will be collected during the pilot-scale treatability study.

## **9.6 SAMPLE COLLECTION, PRESERVATION, AND HOLDING TIMES**

Sample collection, preservation, and holding times are addressed in the Work Plan.

## **9.7 SAMPLE COLLECTION LOG**

A sample collection log will be completed for each sample collected as specified in the Work Plan.

## **9.8 SAMPLE CUSTODY AND DOCUMENTATION PROCEDURES**

Evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal will be provided by the Project Manager. Documentation will be accomplished through a chain-of-custody record, that lists each sample and the individuals performing the sample collection, shipment and receipt. The chain-of-custody will be implemented in accordance with SOP Section 1.1.

## **9.9 REPORTING**

Upon completing the analysis of the samples, the laboratory will provide to the Project Manager a written report on the results of the various tests performed for each sample. Each report will contain the time and date that the sample was analyzed, results of the analysis, reporting limits of each of the tests conducted, and a laboratory QA/QC report.

## **10. ANALYTICAL ACTIVITIES**

Analyses to be performed for this project are identified in the Work Plan and laboratory procedures to be followed and addressed in Section 10 of the CQCPP.

The integrity and documentation of sample custody starts when cleaned and preservative-prepared sample containers are shipped to the field under custody. Samples shipped to laboratories from the field are received by the sample custodian. Upon receipt in the laboratory, the integrity of the shipping container is checked by verifying that the custody seal is not broken. The internal cooler temperature will be measured by means of a temperature blank. Sample containers will be verified against the chain-of-custody. Chain-of-custody forms will be checked for accuracy and completeness, and receipt conditions are documented on the chain-of-custody. If the samples and documentation are acceptable, each sample container is assigned a unique laboratory identification number from the laboratory. If the samples, documentation, or coolers are not acceptable, the Project Manager should immediately be notified to correct any problems.

## 11. REPORT PREPARATION AND DATA REDUCTION/VALIDATION

Requirements for preparation of reports are provided in Section 11 of the CQCPP.

This section describes the approach to be used to reduce, validate, report, and manage collected data. Accurate data reduction, validation, and reporting protocol are necessary to interpret data and arrive at decisions. Standard methods that will be used at Site 13 are described herein.

The **data reduction** procedures provided in SW-846, ASTMs, CLP, and other specified methods or referenced in this plan will be followed where applicable. These procedures specify the methods used to obtain and reduce analytical data including calculations of method internal standard recoveries, surrogate recoveries, response factors, peak identification, calibration curves, and sample results. If a deviation from these referenced methods is made, the laboratory will be required to document this change in the project case narrative section of the data package.

The **data validation** of the project analytical data will be an ongoing process that will be performed by both the analytical laboratory generating the data and UCB's Project Manager. The initial step of the data validation process will be performed by the analytical laboratory. During this review, the calculations, QC sample data, spike recovery, instrument performance indicators, and project specification will be thoroughly inspected through peer level review prior to its release to the laboratory Project Manager. Any problems or nonconformance issues encountered during the analysis will be noted in the project case narrative that precedes each data package. Where inexplicable variations appear, calculations will again be checked for errors and the sample collection and analytical procedures reviewed to identify any causes for the inconsistencies. All calculation errors will be corrected and anomalies in the sampling or analytical procedures documented and reported in the project analytical data package. The raw data will be QC reviewed for technical correctness by the laboratory Project Manager before final printing. After the data package has been completed, the transcription of 100% of the data is verified/validated by the laboratory QC Manager. The laboratory QC Manager will also review the data for conformance to the project data quality objectives. The UCB Project Manager will be notified of any existing problems and will be updated as conditions dictate. All data collected during the project will be reviewed and flagged with the appropriate data qualifiers before reporting. Detection limits will vary with sample types and levels of interferences associated with the sample matrix. If anomalous results are obtained, every effort will be made to identify any problems in the sample collection, sample preparation and/or analysis that could have contributed to the anomaly. In the event any problems have occurred, they will be reported and will include the results, along with the appropriate qualifier and an estimate of the impact the problem may have had on

the data. If the sample results do not conform to the data quality objectives, the data will be thoroughly reviewed in order to identify any existing problems and the sample analysis will be repeated if deemed necessary.

Following the analytical laboratory data review, the sample data will be submitted to the UCB Project Manager.

## **12. REVIEW OF WORK ACTIVITIES**

Requirements for review of work activities are provided in Section 12 of the CQCPP.

## **13. INSPECTIONS**

Requirements for inspections during the Site 13 project are provided in Section 13 of the CQCPP.

## **14. CALIBRATION AND MAINTENANCE OF MEASURING AND TEST EQUIPMENT**

Laboratory and field measuring and test equipment (M&TE) will be calibrated prior to being used for the Site 13 project activities and at prescribed intervals thereafter. Requirements for calibration and M&TE are provided in Section 14 of the CQCPP.

## **15. TEST CONTROLS**

Requirements for the controls to be implemented for the performance of the SEE treatability studies for Site 13 are provided in Section 15 of the CQCPP.

## **16. NONCONFORMANCE CONTROL AND CORRECTIVE ACTIONS**

Items, processes, and services that do not meet established requirements during the treatability study activities will be identified and controlled. The need for corrective actions occurs when a circumstance arises that has a negative impact on the quality of the data generated during a project's activities.

Nonconformance control and corrective action procedures for Site 13 are described in Section 10.2 of the SQP and in Section 16 of the CQCPP.

## **17. CHANGE CONTROL**

Change control and field work variance requirements are provided in Section 17 of the CQCPP.

## **18. AUDITS AND SURVEILLANCE**

Requirements for performance and system audits and surveillance are provided in Section 18 of the CQCPP. The Division QA/QC Manager or the CQC Manager will be responsible for audits and surveillance.

## **19. RECORDS MANAGEMENT**

Records management, including the indexing, filing, and storage of the project files, will be performed only by authorized personnel and maintained in a central filing system. Requirements for records management are provided in Section 19 of the CQCPP.

## **20. REPORTING**

The reporting requirements for the treatability study at Site 13 include a Field Activity Daily Log, a Field Work Variance Report, a Nonconformance Report, Corrective Action Requests, and a Preparatory Inspection Report. Detailed requirements for these reports are provided in Section 20 of the CQCPP.

## **21. DEFINABLE FEATURES OF WORK**

The definable features of work are listed below. Each of these features is separate and distinct and will require separate control measures. Tasks will include:

- Preparation of design drawings and specifications

- Site mobilization:
  - Perimeter fencing
  - Project trailer
  - Utility hook-up
- Survey and site grading
- Drilling and well installation
- Installation of well equipment
- Installation of surface containment system
- Installation of treatment equipment
- Operation of the system
- Laboratory analyses

## **22. REFERENCES**

CONTRACTOR QUALITY CONTROL PROGRAM PLAN

STANDARD QUALITY PROCEDURES

STANDARD OPERATING PROCEDURES

## **ATTACHMENTS**

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### STANDARD QUALITY PROCEDURE

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<u>SQP No.</u>	<u>Title</u>	<u>Rev.</u>
SQP 1.1	Contractor Quality Control Program	0
SQP 3.1	Project Self Assessment	0
SQP 3.2	Indoctrination and Training	0
SQP 4.1	Document Control	0
SQP 4.2	Records Management	0
SQP 5.1	Preparation, Revision and Approval of Plans and Procedures	0
SQP 6.1	Preparation, Review and Approval of Procurement Documents	*
SQP 7.1	Quality Inspections and Inspection Records	0
SQP 8.2	Calibration and Maintenance of Measuring and Test Equipment	0
SQP 9.1	Control of Tests	*
SQP 10.1	Nonconformance Control	0
SQP 10.2	Corrective Action	0
SQP 10.3	Stop Work Order	0
SQP 11.1	Field Work Variance/Request For Information	0
SQP 12.1	Quality Audits	0
SQP 12.2	Management Assessment	0
SQP 12.3	Quality Surveillances	0

\*NOTE: Procedures denoted by an asterisk are to be developed in the future.

Approved: \_\_\_\_\_ Date: \_\_\_\_\_  
Program CQC Manager

Approved: \_\_\_\_\_ Date: \_\_\_\_\_  
Program Manager



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### STANDARD OPERATING PROCEDURE

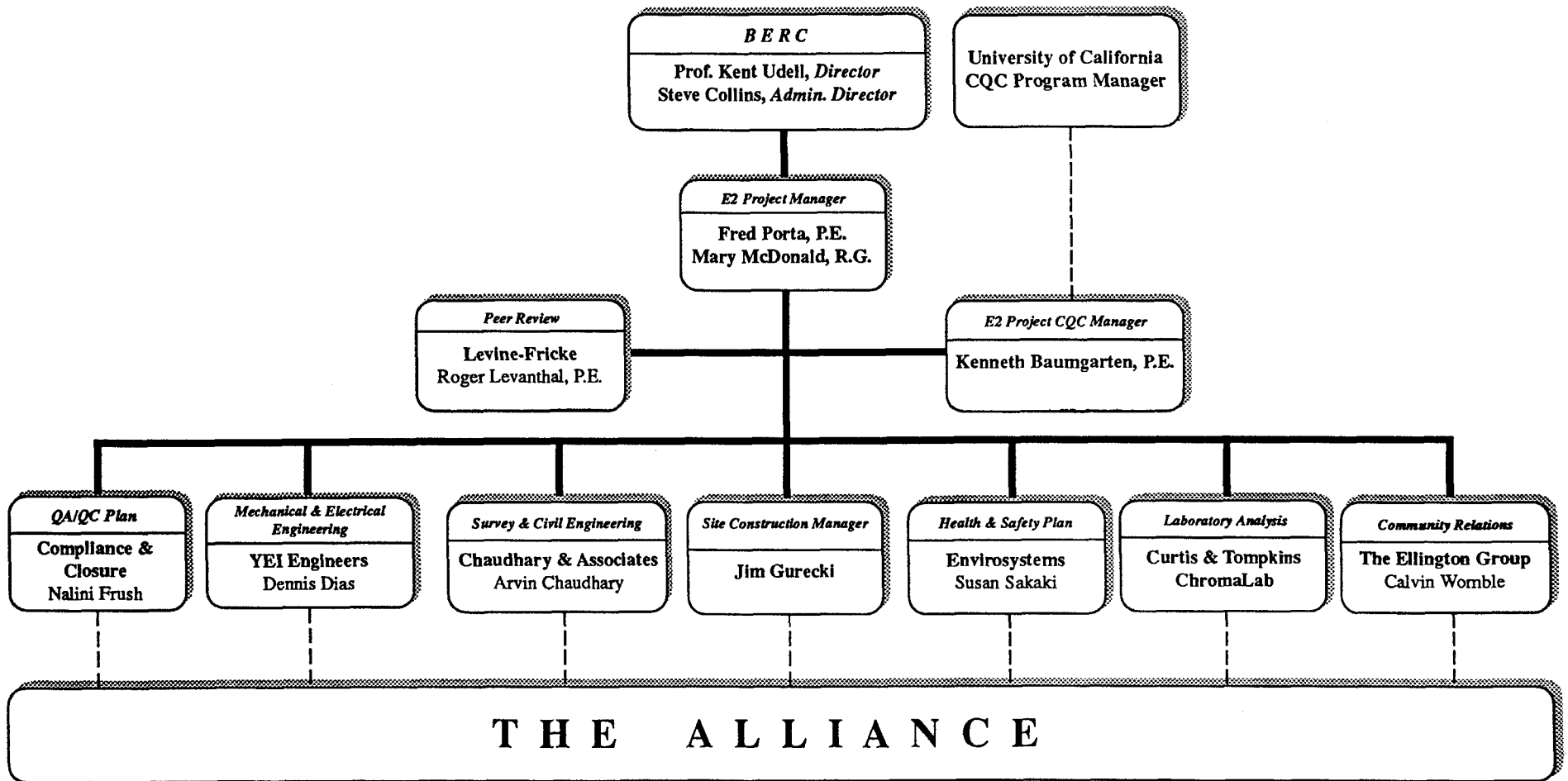
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<u>SOP No.</u>	<u>Title</u>	<u>Rev.</u>
SOP 1.1	Chain of Custody	0
SOP 2.1	Sample Handling, Packaging and Shipping	0
SOP 3.2	Subsurface Soil Sampling While Drilling	0
SOP 5.1	Water Level Measurements in Monitoring Wells	0
SOP 5.2	Nonaqueous Phase Liquid Measurement in Monitoring Wells	0
SOP 6.2	Drilling and Heavy Equipment Decontamination	0
SOP 8.1	Monitoring Well Installation	0
SOP 8.2	Monitoring Well Development	0
SOP 9.1	Groundwater Sampling	0
SOP 10.2	Cone Penetration Testing and Hydropunch Groundwater Sampling	0
SOP 17.1	Sample Labeling	0
SOP 17.2	Sample Numbering	0
SOP 18.1	Field QC Sampling	0
SOP 19.1	On-Site Sample Storage	0
SOP 23.1	Land Surveying	0

NOTE: THESE ARE DRAFT SOPS IN THE PROCESS OF BEING FINALLIZED. ALL REFERENCES TO DELIVERY ORDER MANAGER WILL BE CHANGED TO PROJECT MANAGER.

# **PROJECT ORGANIZATION AND RESUMES**

**Figure B-1**  
**E2 Project Organization**  
**BERC/NAS Alameda Innovative Technologies**



**FRED R. PORTA**  
**Marketing Director/Chief Engineer**

**Education**

MBA, Stanford University, 1960.  
BS, Architectural Engineering, Kansas University, 1958.

**Professional Registrations**

Registered Civil Engineer, California, 1967, No. 17642.  
Security Clearance, DOE "Q" (Inactive)

**Experience**

Fred Porta has more than 30 years of experience in project management, engineering design, estimating, marketing, and administration. As chief engineer with E2, Mr. Porta is responsible for providing marketing services, project administration, and project management services. Previously, as a vice president with Kal Krishnan Consulting Services, Mr. Porta served as project manager and corporate sponsor for various government projects and managed the marketing activities. With ICF Kaiser Engineers he was a project manager, marketing manager, and project engineer.

- Project manager for a task order contract to provide scheduling support services in conjunction with the \$25-million Construction Package V - Building 132 at Lawrence Livermore National Laboratory. The services include CPM scheduling, quality assurance audit analysis, and computer-aided drafting and design and drafting (CADD) support. The Building 132 is an office/laboratory complex which includes sophisticated clean/dry labs, chemistry labs, and secured office space.
- Project manager for indefinite delivery/indefinite quantity task order engineering and construction management services contract for the U.S. Coast Guard in California, Washington, and Oregon. Assignments included engineering and biennial assessment of Group San Francisco facilities; inspection of underground storage tank removal (UST) removals; survey and structural analysis of Piers 36/37 in Seattle; inspection of pier rehabilitation in San Diego; design of renovation to the station buildings and family housing units in Oxnard; HVAC upgrades in San Diego; planning and design of security and fire alarm systems at Alameda and Bolinas; and design of a hanger deluge system at San Diego.
- Project manager for "on-call" value engineering studies for the California Department of Transportation (Caltrans) District 11. The services include evaluating highway design projects and construction administration procedures throughout District 11.
- Planned and coordinated various projects for street paving, signalization, parking lots,

plus traffic, safety and planning studies while assigned to Lawrence Livermore National Laboratory. Also prepared staff reports and studies, findings, and determinations, and coordinated with outside consultants and local agencies. Helped coordinate the NEPA documentation for the civil planning activity.

- Managed a \$5-million A/E services contract, including planning, design, and inspection services for laboratory and research facilities in 8 states for the U.S. Department of Agriculture Research Service. Work included renovation of the 50-year-old Albany laboratories and several asbestos surveys and development of asbestos removal plans.
- Managed design of a 450-bed Hilton Hotel in Jeddah, Saudi Arabia. (Architectural and structural design and coordination of subconsultants was done in London.) Also was administrative manager for various architectural projects, including a worldwide expansion program for Sheraton Hotels and design of eight new medical facilities for Kaiser Foundation Hospitals.
- Performed design and project administration engineering services on various projects for U.S. Department of Energy (DOE) nuclear facilities at Richland, Washington; Los Alamos, New Mexico; and Livermore, California. Project included disposal/storage of high and low level wastes, special nuclear materials storage building, and support services.
- Managed various tasks that included clean rooms, environmental and production facility modernization at the IBM disk manufacturing facility in San Jose, California. Work included conceptual design and detail design of a system for removing sub-micron aluminum/alumina from the industrial waste water system and for compacting flammable aluminum dust and chips removed from the ventilation system, and pilot plant testing.
- Prepared successful proposals for various major projects, including the On-site Architect-Engineer/Construction Services at DOE's Hanford Works, the Superconducting Super Collider, and task order A/E services for the General Services Administration in Washington, DC, and at the Lawrence Livermore and Los Alamos National Laboratories.
- Managed energy conservation projects at Lawrence Livermore National Laboratory, the VA Hospital at Livermore, and the Kaiser Foundation Hospital in Santa Clara. Provided administrative engineering services for industrial environmental control projects in Pennsylvania, Missouri, and California. These projects included fume and dust control systems for 10 electric furnaces and a blooming mill hot scarfer, lead blast furnace, and a periclase plant.
- Oversight for the Phase II Environmental Survey for a BART Warm Springs Extension

project, including data collection, generation of documentation, including the project final report.

- Oversight for the I-880 freeway project repair and modifications to the extension from Oakland to Fremont, California.
- Provided staff estimating for the Hyperion Full Secondary wastewater treatment facility for the City of Los Angeles.
- Prepared quantity takeoffs on the renovation and addition of the historic Kendall Hall housing the Fine Arts Department and Theater building at Trenton State College, New Jersey. Facilities included the theater, auditorium, change rooms, rehearsal halls, and administration offices. Addition was designed to match older portions of the facility.
- Managed various commercial and institutional projects, including the planning, environmental impact assessment, and design of the Kings County Government Center in Hanford, California. Also planned and designed the \$6-million addition to the Kings County court facilities. The project included evaluation of renovation the historic Kings County Courthouse and the County Hospital Buildings.
- Provided planning and design services for the \$15-million modernization of the communications and high-voltage power distribution systems at the University of California at Berkeley. Earlier, managed physical and environmental studies for modernization and renovation of 30 older buildings at University of California at Berkeley.
- Managed planning and structural design of the Alameda County Court and Detention Center facilities in Oakland and Hayward, California. Project included court rooms, detention cells, judge's chambers, jury rooms, and support facilities.
- Performed inspection at factory of fabricated transition sections for the ventilation system for the Los Angeles Metro Rail project.
- Responsible for cost control, contract administration, and administrative support, hospital planning, interior design, and design of eight new medical facilities for Kaiser Foundation Hospitals, including the 12-story, 480-bed tower structure above an existing hospital in Oakland; a 200-bed medical center in San Diego; a 100-bed addition to the hospital in Bellflower; a 200-bed medical center with facilities for 86 doctor's offices in West Los Angeles; a 5-story addition to provide 281 beds, a 2-story clinic to house 125 doctor's offices, and the 88,000 sq. ft. medical office building in Sacramento; and a 130,000 sq. ft. medical office building in Santa Clara.

**MARY LUCAS McDONALD**  
**Geologist**

**Education**

B.A., Geology, Carleton College, 1981.

**Professional Registration**

Registered Geologist, California, 1992, No. 5506.

**Professional Training**

OSHA 40-hour Health and Safety

**Experience**

Ms. McDonald is the E2 project manager for the underground storage tank removal and building demolition at a MacArthur Station site for the BART Hazardous Materials Programs; and the tank removal at the Balboa Park maintenance yard and the drum disposal at the Kirkland bus yard for the San Francisco Municipal Railway.

Previously with Harding Lawson Associates, Ms. McDonald was project manager for the CERCLA investigation of Hunter's Point Annex in San Francisco. Technical tasks included the assessment of soil and groundwater at 16 identified sites within the facility; preliminary assessments of 44 sites and implementation of site inspections at two; planning of removal actions at three sites including air modeling to assess potential health risks from two of the removal actions; planning for sediment, water, and tissue sampling to assess the potential impact of the facility on San Francisco Bay; and planning of an environmental risk assessment to assess the potential risk to local biota. Responsible for primary client contact, regulatory agency contact, subcontractor overview, development and maintenance of project budget and schedule, review of technical documents, and budget and contract negotiations.

Earlier with Brown and Caldwell Consultants, Ms. McDonald was initially responsible for conducting field work and report preparation. Promoted to project manager, was responsible for project budgeting and scheduling, staff supervision, technical review, regulatory agency and client contact, and business development activities. Planned and implemented projects in accordance with Title 22, Title 23, and underground storage tank regulations. Trained in site safety practices in accordance with OSHA regulations. Experienced in field quality assurance/quality control methods. Assessed soil and groundwater contamination by petroleum products, organic solvents, pesticides, and metals at numerous sites and implemented site remediations. Projects included:

- Project hydrogeologist for the site investigation and remediation of a chemical blending and packaging plant in Santa Clara Valley. Responsible for development of the technical

approach to the investigation and remediation of site soil and groundwater containing primarily halogenated hydrocarbons. Implemented soil vapor surveys and groundwater monitoring well installation to investigate the distribution of organics in the on and off site soil and groundwater. Negotiated with the San Francisco Bay Regional Water Quality Control Board on approach to evaluate potential contribution from off site sources and on the on site groundwater remediation. Provided oversight of the implementation of a pilot scale soil venting system to remediate site soils near the above ground tank farm. Submitted application for permit to operate the full scale soil remediation.

- Project manager for the investigation and remediation of soil containing DDT at an airport in the Central Valley. Excavation and class I disposal, capping, and fixation were evaluated.
- Project geologist for the site investigation at a Los Angeles refinery for a major oil company. Developed the technical approach for the soil and groundwater quality investigation and conducted the field work. Prepared the final report presenting the methods and results of the investigation. Developed the technical approach to the investigation of a previous waste disposal site at the refinery and provided oversight for its implementation.
- Office coordinator for site investigations and remediations of underground storage tanks at 17 service stations in the San Francisco Bay Area for a major oil company. Responsible for project scheduling, development and review of cost estimates, and review of work products for consistency and technical quality. Acted as the primary client contact for scheduling and development of new work.
- Project manager for underground storage tank project at numerous service stations. Developed the technical approach and provided oversight for tank removal, site investigations, and remediation. Implemented a groundwater remediation and evaluated remedial options for the soil.
- Project manager for the soil and groundwater remediation at a former gasoline service station being developed as a motel in Santa Cruz, California. Developed groundwater treatment system for groundwater produced during normal dewatering activities.
- Project manager of a preliminary environmental assessment of 10 sand and gravel operations and one golf course in northern California. Evaluated the presence of hazardous materials and/or wastes and their potential environmental affects at each site. Reviewed property ownership records and aerial photographs to identify indications of past use, storage, or disposal of hazardous materials or wastes. Reviewed ongoing investigations at nearby sites to identify whether they could impact the sites being assessed.



**KENNETH R. BAUMGARTEN**  
**Quality Engineer**

**Education**

AA., Preengineering, American River College.  
Mechanical Engineering, California Coast University

**Professional Registration**

Professional Engineer-Quality, California, 1978.

**Experience**

Mr. Baumgarten is a quality engineer with more than 25 years of experience in the development, implementation, and management of quality assurance and reliability programs for a variety of projects and facilities for the military, nuclear, aerospace, and heavy industrial industries. His work has included the development of quality projects; the evaluation of quality assurance programs for compliance to regulatory requirement; and the inspection of materials and equipment at subcontractor and supplier facilities. He has been the Manager of Compliance and the Corporate Lead Auditor for a major Oakland, California, engineering and construction firm. Currently, he is the E2 Contractor Quality Control Manager for the pilot-scale treatability study being conducted at NAS Alameda for the partnership between the University of California at Berkeley and the U.S. Navy.

**Quality Assurance Program Development**

- Relocation of NAS Miramar to NAS Lemoore, California. Responsible for quality assurance development support as part of the transition team directing the construction activities required for the relocation.
- Fuel Processing Restoration Project, Idaho National Engineering Laboratory, Idaho. Coordinated the preparation of the proposal of the Title II inspection services and participated in the successful negotiation of the five-year contract for the project. Also assisted in the development of the Project Quality Assurance Program in compliance to specific project and regulatory requirements.
- National Test Facility, Colorado Springs, Colorado. Prepared the quality assurance portion of the proposal and participated in the development of the quality program for construction activities of the National Test Facility to support the SDI Program.
- Tinker Air Force Base, Building 3001 Restoration Project, Tulsa, Oklahoma. Developed an effective quality control program, and procedures for procurement, construction, and test activities related to the restoration of production facilities for the overhaul of U.S. Air Force jet engines.

**JAMES M. GURECKI**  
**Construction Manager**

**Education**

B.S., Construction Engineering, Georgia Tech

**Experience**

James Gurecki has 26 years experience in the construction industry with a broad background in the areas of infrastructure, airports, microelectronics, distribution and warehousing, food processing and light industrial manufacturing. He is thoroughly familiar with all aspects of preconstruction services, scheduling, construction management, and construction services. He is responsible for the performance of personnel, maintaining the quality of work, and client relationships. He consults and checks all overall budgets, estimates, schedules, and advises on major preconstruction and construction phase decisions. He visits all projects on a monthly basis to review progress with the client and design team. He possesses outstanding skills in project planning, project control systems, cost control and scheduling. Mr. Gurecki has a very strong background in quality assurance/quality control.

- Construction manager for Avery Middle School project.
- Constructability review of new EE/Computer Science Building at the University of Washington.
- Construction manager for various school projects in California.
- Operations manager/project controls manager for providing project management oversight services for the construction of High Occupancy Vehicle Lanes for the northwest and southwest freeways in Houston, TX, and oversight for Urban Mass Transit Administration at Washington, D.C.
- Responsible for providing construction management services on the construction of a \$88 million waste treatment facility utilizing multiple prime contracts in the City of Orlando, FL.
- Division manager responsible for providing program management, construction management and right-of-way services for completion of the freeway extension of I-595 in Fort Lauderdale for the Florida Department of Transportation. The project included right-of-way procurement, massive utility relocations and the relocation of a railroad in addition to the construction of the freeway and interchanges.
- Division manager responsible for providing design and construction management services for the construction of a new 60,000 sq. ft. class 1,000 manufacturing facility for SEH America, Inc. Project included high purity gas and water systems and hydrogen recovery system.
- Division manager providing construction management services to AC Transit on the construction of three bus maintenance facilities located in Oakland and Emeryville, CA. Facilities included all operations required for complete bus maintenance as well as site development and parking structures.

**JAMES M. GURECKI, page 2**

- Operations manager at Acute Care Hospital in Corcoran, CA. Responsible for providing construction management services for the construction of a new 50-bed acute care hospital located within an occupied corrections facility for the California Department of Corrections.
- Responsible for the Convention Center Expansion for the City of Miami Beach, FL, providing construction management services to add an additional 350,000 squ. ft. addition to the existing convention center. Clear spans reached 200 feet utilizing field assembled walk-through trusses shop fabricated for maximum roadway transit Schedule requirements dictated completion to meet future scheduled conventions.
- Project manager for the Detention Facility Support Facilities at Jackson, CA. Provided construction management services for the construction of support buildings at the new Sierra Conservation Facility for the California Department of Corrections.
- Project manager at New Correctional Facility at Ione, CA. Responsible for providing construction management services to the construction manager for site utilities, water treatment plant, wastewater treatment plant and wastewater reservoir for the California Department of Corrections.
- Responsible for providing scheduling support services to the construction manager for the reconstruction of the main library rehabilitation for the City of Los Angeles.
- Provided construction management services for the construction of a central plant for the new West Campus for Arizona State University, Tempe, AZ.
- Department manager for an Arco Research Facility Expansion in Plano, TX, providing construction management services during construction of a computer center building expansion.
- Served as in the US Navy in the Seabees as a Petty Officer, 2nd Class, assigned to MCB3. Service included two tours to Vietnam and a special assignment as a member of the Display Team commemorating the 25th anniversary of the Seabees.

**EDWARD A. ROLLERSON**  
**Construction Engineer**

**Education**

B.S., Construction Management, California State University, Long Beach, 1989.

**Professional Training**

OSHA 40-hour Health and Safety

**Experience**

Mr. Rollerson has more than 10 years of experience in the construction industry, including subcontract administration, change orders, cost estimating, and CPM scheduling (Primavera P3).

Currently, Mr. Rollerson is responsible for schedule and cost control visibility studies and capacity and resource loading on over 1,200 field activities in support of the environmental cleanup at the Presidio of San Francisco.

He was a senior construction engineer for E2 on assignment to the California Department of Transportation (Caltrans) in District 4 where he served as assistant structure representative on the seismic retrofit of three bridges in the San Francisco Presidio; and assistant resident engineer/acting resident engineer for Caltrans San Francisco maintenance station and field office engineer for several Caltrans bridge contracts. Duties have included overall project documentation, field inspection and reporting, material sampling, and the review and approval of contract submittals including shop drawings, concrete mix designs, and shoring plans. Performed plan/specification review, claims analysis, change order negotiation, staff supervision and coordination of hazardous waste removal activities.

Previously, on the Los Angeles Metro Rail Wilshire/Normandie Station and Tunnels project, he was a change order/claims/field engineer for the general contractor. Responsibilities included contract administration as well as the investigation, review, analysis, and subsequent resolution of changed conditions and potential claims through effective change order negotiations with the owner. Field engineering duties included the resolution of construction and design conflicts, coordination of field work, material purchases, and liaison between structural designers and field personnel.

As a cost/schedule engineer on the Los Angeles Metro Rail Civic Center Station and Tunnels project, duties included cost coding, budget updates, schedule revisions and updates, quantity takeoffs and reporting, monitoring of time-and-material work, change order estimation and negotiation, claims analysis and submittal, owner payment requests, and subcontracts administration.

**EDWARD A. ROLLERSON, page 2**

Earlier with Miner-Daderick Construction Corporation, assisted with project layout, reviewed and checked blueprints for dimensional accuracy, inspected subcontractor activities, and established project control lines and elevations for a commercial office building.

With the Charles Pankow/Construction Specialties joint venture, constructed and set concrete forms for supported slabs, walls, and columns for a commercial hotel/office complex in downtown Long Beach.

With Jolyn Investment Company, assisted with concrete quantity takeoffs, maintained dewatering system, formed and set precast concrete walls, and performed general rough carpentry for an office building in Beverly Hills.

Earlier, with Peter Shultz Construction Company, assisted on various single-family home remodeling projects.

## **APPENDIX C**

### **SITE HEALTH AND SAFETY PLAN**

**SITE HEALTH AND SAFETY PLAN**

**SITE 13**

**NAVAL AIR STATION, ALAMEDA**

**June 21, 1995**

**Approved by:** \_\_\_\_\_ **Date:** \_\_\_\_\_  
**Fred Porta, E2 Project Manager**

**Approved by:** \_\_\_\_\_ **Date:** \_\_\_\_\_  
**Mark Freiberg, BERC Program CIH**

## **1. PURPOSE AND SCOPE**

This Site Health and Safety Plan (SHSP) is prepared as a site specific supplement to the program level Health and Safety Plan Volumes 1 and 2 dated June 8, 1995. It establishes the basic safety guidelines and requirements for the activities and operations associated with the Steam Enhanced Extraction (SEE) Pilot Scale Treatability Study at Site 13, Naval Air Station (NAS), Alameda. This SHSP addresses hazards that may be encountered during this project and the actions that will be taken to mitigate, lessen or respond to those hazards. Activities will be performed by personnel associated with the Berkeley Environmental Restoration Center (BERC), E2 Consulting Engineers (E2), and various subcontractors. The numbering of sections that follow correspond to major section numbers in the program-level Health and Safety Plan.

The provisions set forth in this SHSP shall apply to BERC or E2 personnel and any subcontractors working at the job site. All site personnel must read this SHSP and sign the attached Compliance Agreement before entering the work area.

Field personnel may deviate from the safety provisions set forth in this SHSP, but only to upgrade or increase the safety requirements. If changes in site or working conditions require changes in safety procedures, appropriate amendments to this SHSP will be made under the direction of the Site Health and Safety Officer (SHSO) and the Program Certified Industrial Hygienist (CIH).

## **2. KEY SAFETY PERSONNEL AND RESPONSIBILITIES**

All site personnel are responsible for project safety. The specific responsibilities of personnel are stated in Section 2 of the Health and Safety Plan. The operational and health and safety responsibilities of pertinent personnel are identified below.



**Project Manager: Fred Porta, P.E.**

The Project Manager has the responsibility to ensure all provisions of the SHSP are followed and to contact the program CIH for variances or modifications. The Project Manager has the authority to inspect and audit compliance with the provisions of this SHSP and to take corrective actions; report to the Program CIH or the Resident Officer in Charge of Construction (ROICC) any reportable incidents; ensure the Field Activity Daily Log (FADL) forms are completed, signed, and dated; and notify the Program CIH of regulatory agency inspection. The Project Manager is also responsible for the documentation associated with this SHSP. This documentation shall include all internal and external health and safety correspondence, including this SHSP; all air monitoring data (from the work site and the perimeter areas); all accident reports and Accident Review Board documentation; documentation of audits and corrective actions; air monitoring equipment calibration records; and the FADL forms.

**Program Certified Industrial Hygienist: Mark Freiberg, CIH**

The Program CIH shall implement and oversee the health and safety program for NAS Alameda, and shall develop, implement, and sign SHSPs. Any changes to the SHSP shall be with approval of the CIH with concurrence of the Contracting Officer. The Program CIH shall be available for consultation when required.

**Project Superintendent (PS): Jim Gurecki**

The Project Superintendent (PS) reports to the Project Manager and is responsible for the field enforcement of the SHSP. His/her responsibilities include communicating the project health and safety requirements to all on-site project personnel; conducting periodic health and safety inspections with the Site Health and Safety Officer; directing work to ensure personnel safety and protection of property and the environment; providing required safety supplies to work crews prior to each task; correcting any hazards found; and rendering appropriate disciplinary action to individuals who do not adhere to the project SHSP.

**Site Health and Safety Officer:     Judy Cook**

The SHSO is responsible for ensuring that all site personnel have received, read, and signed the SHSP; providing independent surveillance of the implementation of the SHSP; immediately stopping work if dangerous or extremely hazardous conditions are encountered; conducting and documenting required project-specific training; and conducting job site safety audits at least daily.

The SHSO is responsible for ensuring the following items are adequately addressed:

- Medical surveillance program/physical examinations
- Training programs/hazard communication
- Compliance with the SHSP
- Decontamination/contamination procedures
- Monitoring of personnel at the work site and at the perimeter of the site
- Inspection and calibration of safety equipment as required.

The SHSO will be present during the field work operations, or an alternate SHSO will be designated and present when the SHSO is not on-site.

### **3.     JOB HAZARD ANALYSIS**

The major contaminants that are expected to be encountered are crude oil, the hazardous components associated with petroleum hydrocarbons, and pesticides. The majority of the contamination appears to be below the water table at 4 to 5 feet below ground surface. Table 3-1 lists the chemicals found in the soil to date with maximum concentrations and associated limits for explosion and permissible personnel exposure.

If levels of contaminants in soil are found above the maximum concentrations shown above, the SHSO shall, if necessary, stop operations to reassess if worker health and safety safeguards are adequate.

### 3.1 FIRE/EXPLOSION HAZARDS

The potential for fire or explosion exists whenever flammable liquids or vapors are present above the lower explosion limit (LEL) concentrations and sufficient oxygen is present to support combustion. The potential for fire and/or explosion exists during the treatment of the extracted oil/water mixture. At this time, the concentration and constituents of the extracted vapor from wells are not known. Volatile vapors will be present in the overhead of the liquid/vapor separator and will be destroyed in a thermal oxidation unit.

Table 3-1 CHEMICALS FOUND IN SOIL

Chemical	LEL-UEL	PEL	Max. Conc.
<b>VOLATILES</b>			
Benzene	1.3%-7.1%	1 ppm	1 ppm
1-2, Dichloroethene	5.6%-12.8%	200 ppm	5 ppb
Methylene chloride	13%-23%	500 ppm	160 ppb
Methyl ethyl ketone	1.4%-11.4%	200 ppm	5 ppb
Toluene	1.1%-7.1%	200 ppm	1.6 ppm
Xylene	1.0%-6.0%	100 ppm	4.1 ppm
<b>SEMIVOLATILES</b>			
Anthracene	0.6%-N/A	N/A	100 ppb
1,2-Benzanthracene	N/A	N/A	390 ppb
Benzo(a)pyrene	N/A	0.2 mg/m <sup>3</sup> (coal tar pitch volatiles)	520 ppb

Benz(e)acephenanthrylene	N/A	N/A	1.1 ppm
Benzo(g,h,i)perylene	N/A	N/A	1.4 ppm
Benzo(k)fluoranthene	N/A	N/A	510 ppb
Chrysene	N/A	0.2 mg/m <sup>3</sup> (coal tar pitch volatiles)	2.3 ppm
Ethylbenzene	0.8%-6.7%	100 ppm	1.8 ppm
Fluoranthene	N/A	N/A	800 ppb
Indeno(1,2,3-cd)pyrene	N/A	N/A	690 ppb
2-Methylnaphthalene	N/A	N/A	17 ppm
Naphthalene	0.9%-5.9%	10 ppm	5.4 ppm
N-Nitrosodiphenylamine	N/A	N/A	2.7 ppm
Pentachlorophenol	N/A	0.5 mg/m <sup>3</sup>	1 ppm
Phenanthrene	N/A	0.2 mg/m <sup>3</sup> (coal tar pitch volatiles)	1.8 ppm
Pyrene	N/A	0.2 mg/m <sup>3</sup> (coal tar pitch volatiles)	1.9 ppm
<b>COAL TAR PITCH VOLATILES</b>			
Fluorene	N/A	N/A	790 ppb
<b>PESTICIDES</b>			
b-BHC		0.5 mg/m <sup>3</sup> (German standard)	3.5 ppb

4,4'-DDD	N/A	N/A	14 ppb
4,4'-DDE	N/A	N/A	35 ppb
4,4'-DDT	N/A	1 mg/m <sup>3</sup>	160 ppb
Heptachlor epoxide	N/A	0.5 mg/m <sup>3</sup>	5.4 ppb
Toxaphene	N/A	0.5 mg/m <sup>3</sup>	2.5 ppm

LEL = Lower Explosive Limit  
 UEL = Upper Explosive Limit  
 PEL = Permissible Exposure Limit (OSHA) based on 8-hour time weighted average (TWA); inhalation limit  
 Max. Conc. = Maximum concentration found in soil known at this time  
 N/A = No available information or not applicable

Ignition sources, smoking, or open flames shall be excluded from the treatment pad area and for a radius of 25 feet of the treatment pad. Daily monitoring of the treatment pad area and peripheral boundary of the fence using a combustible gas indicator (CGI) shall be performed by the SHSO. These results shall be noted in the FADL. Monitoring shall occur as often as considered necessary by the SHSO according to the type of site activities being performed. Failure of the thermal oxidation unit shall trigger an alarm and notification of site personnel.

### 3.2 CHEMICAL HAZARDS

The primary routes of exposure for the petroleum hazard are inhalation and ingestion. Worker exposure will occur primarily during the drilling and logging of the injection/extraction wells, temperature monitoring wells, and electrode wells; and the sampling associated with the wells. During these operations, worker health and safety will be ensured by air monitoring with a photoionization detector (PID) or equivalent field sampling equipment. If use of the PID indicates high levels of volatile contaminants, the combined CGI/oxygen meter will be utilized to ensure safe conditions. The SHSO shall record and

document personnel monitoring and/or ensure the results are noted in the FADL form.

The treatment pad will be monitored for chemical hazards as well as fire/explosion potential as noted above. The area shall be monitored prior to entry by operators or personnel.

Ingestion of the hazardous compounds will be minimized by following proper decontamination procedures, washing hands after leaving the control area, and allowing eating, drinking, smoking, and applying cosmetics in designated areas only.

### **3.3 PHYSICAL HAZARDS**

The potential physical hazards expected at the job site are addressed below:

- The potential for physical injury exists from the operation of machinery such as pumps, blowers, and heavy equipment. Use of steel-toed boots or shoes, hard hats, and safety glasses will be required when in the work area.
- The potential for noise hazards exists at the site from the operation of various equipment, including heavy earth-moving equipment, pumps, and blowers. The SHSO shall perform sound level monitoring or noise dosimetry on operations which may exceed 85 dBA, or wherever voices must be raised in order to be understood at arm's length.
- Compressed air and steam will be used for well extraction and for treatment of the extracted vapor. Procedures outlined in Section 3 of the Health and Safety Plan shall be followed regarding the labeling of lines, lockout/tagout procedures, tie-down requirements, and installation of shutoff valves.
- Dust hazard may occur during the grading of the site and installation of the surface containment systems. Air monitoring and measures to control dust generation as outlined in Section 3 of the Health and Safety Plan shall be followed.

- Drilling hazards are outlined in Section 3 of the Health and Safety Plan. Monitoring as noted in previous sections will be required during drilling operations to ensure health and safety of personnel.
- Personnel should be cognizant of the fact that when protective equipment such as gloves, and protective clothing are worn, visibility, hearing, and manual dexterity are impaired.

### **3.4 HEAT/COLD STRESS**

All personnel should be familiar with the symptoms of heat or cold stress as outlined in Section 3 of the Health and Safety Plan. The SHSO shall monitor and record the daily maximum and minimum temperatures on-site. Additional heat stress monitoring shall be initiated by the SHSO whenever ambient temperatures on-site exceed 85°F, or 78°F when workers are wearing impermeable clothing.

### **3.5 JOB HAZARD SURVEY**

The expected potential hazards to personnel in the work area are:

- Fire/explosion hazards
- Chemical exposure
- Physical hazards
- Heat/cold stress

As described in the previous section, these potential hazards have been mitigated for the protection of the worker's health and safety. The proposed work does not appear to present any potential health risk to the workers, the surrounding community, or the environment if the provisions of this SHSP and the Program Health and Safety Plan are properly implemented.

## **4. [Not used]**

## **5. PERSONAL PROTECTIVE CLOTHING/EQUIPMENT**

Level D protection is the minimum protection level required for this project. The SHSO may require additional protective equipment to the Modified Level D depending on the conditions within the work area. Level C protection will initially be required for drilling operations until personnel monitoring indicates that the level of protection can be safely lowered to a Modified Level D.

The following list summarizes the personal protective equipment that is required for each level of protection:

### **Level D Protection**

- Steel-toed shoes or boots, ANSI approved
- Safety glasses, ANSI approved
- Hard hat, ANSI approved
- Long pants

### **Modified Level D Protection**

- Steel-toed impermeable boots, ANSI approved
- Safety glasses, ANSI approved
- Hard hat, ANSI approved
- Nitrile or other impermeable gloves
- Tyvek coveralls
- Long pants

### **Level C Protection**

- Hard hat, ANSI approved
- Safety glasses, ANSI approved
- Steel-toed impermeable boots, ANSI approved
- Impermeable gloves
- Half-face air purifying respirator with cartridges for organic vapors, NIOSH approved
- Tyvek hooded coveralls
- Full tape at ankles and wrists



Hearing protection shall be made available to all personnel at the job site in the event noise levels exceed worker comfort levels.

If hazard conditions change, the SHSO may modify or stop work, or remove personnel from the site. The SHSO shall contact the Program CIH if the level of protection must be upgraded due to changes in working conditions.

## **6. SITE CONTROL MEASURES**

The project area will be fenced with main access for personnel through the trailer. A lockable gate will provide vehicle access to the work area. Signs are to be posted around the perimeter of the fence identifying the project and person(s) to be notified for access or emergencies.

Site personnel will be present during normal working hours. The SHSO will ensure that the site is secured prior to leaving at the end of each working day. The SHSO will ensure that all personnel have been logged out and recorded on the FADL.

An alarm system will be installed on various equipment that are vital for the safe operation of site activities. This system has not been designed at this time but will include at the minimum an alarm and notification procedure for improper operation or failure of the thermal oxidation unit. A telephone will be installed at the trailer. Alarms may tie into an autodialer to notify off-site personnel of malfunctions or failures.

## **7. DECONTAMINATION MEASURES**

The trailer will be the point of entry for personnel and designated a support zone. The exclusion zone (EZ) and contamination reduction zone (CRZ) will be designated by the SHSO once the site has been secured. These zones may change as different phases of operations and activities occur. The EZ and CRZ areas shall be mapped and posted in the trailer so that personnel and visitors are aware of the locations.

Decontamination procedures as outlined in Section 7 of the Health and Safety Plan will be followed by personnel, vehicles, and equipment leaving the EZ area. Personnel decontamination will consist of removing any gross contamination from outer clothing and boots; then removing Tyvek coveralls, gloves, hard hats, glasses, boots, and respirators if used. Personnel will thoroughly wash their hands and face before leaving the decontamination zone. Respirators shall be sanitized, cleaned, and stored in accordance with OSHA requirements. All contaminated clothing and personnel equipment will be placed in DOT-approved containers for disposal.

All equipment will be decontaminated by steam cleaning or washing with a non-phosphate detergent such as Liquinox or equivalent. Equipment will be rinsed with tap water, isopropanol, and/or deionized water, as appropriate. All waste water generated will be contained or collected until lab analysis is complete.

Soil cuttings from the drilling process will be placed in covered roll-off boxes or DOT-approved 55-gallon drums, sealed, and stored in a secured area until testing as outlined in the Work Plan is completed.

Wastes from laboratory analyses shall be handled in accordance with California and EPA regulations regarding hazardous wastes.

Soil cuttings, waste water and contaminated clothing/equipment may have to be analyzed to determine proper manifesting and disposal method. All containers with contaminated material shall be kept in a secure area and labeled with contents and date of first use.

## **8. EXPOSURE MONITORING PLAN**

The SHSO is responsible for performing, recording, and documenting all monitoring related to personnel exposure. The SHSO and Program CIH shall determine the personnel who may be exposed to hazards and should be monitored. This monitoring shall include:

- Daily monitoring of maximum and minimum temperatures
- Personnel monitoring during drilling operations using PID and CGI/oxygen detector, if necessary
- Monitoring and recording of noise levels if noise approaches 85 dBA
- Monitoring and recording of volatile gas levels at vapor/liquid separator
- Monitoring and recording of combustible gas levels due to site activities at the fence boundary in the prevailing wind direction.

## **9. TRAINING REQUIREMENTS**

Personnel entering the EZ or CRZ must have completed the 40 hours of hazardous waste operations as defined under 29 CFR 1910.120 or California Title 8 CCR 5192. The 40-hour training or the refresher course training must be completed within the past 12 months. Personnel must also have been certified as fit for hazardous waste operations by a physician within the past 12 months. Personnel required to wear respirators must also have been fitted and certified for the respirator used.

Documentation of the 40-hour training, update training, and specialty training, as well as annual medical clearance, shall be maintained at the site for all BERC and subcontractor personnel.

## **10. MEDICAL SURVEILLANCE PROGRAM**

All on-site personnel must complete a comprehensive medical examination within the past 12 months that meets the requirements of 29 CFR 1910.120 or Title 8 CCR 5192. Subcontractors must certify that their employees have completed a physical examination by a qualified physician that meets the requirements of 29 CFR 1910.120 or Title 8 CCR 5192.

All employees must receive a preplacement medical examination prior to assignment to field operations. All employees must undergo an annual examination and exit examination as stated in Section 10 of the Health and Safety Plan.

Workers requiring the use of a respirator must have a letter from the examining physician confirming the fitness for work and ability to wear a respirator.

Copies of medical examination certificates shall be part of the project files. Project files shall also contain all personnel monitoring information and data.

**11. [Not used]**

**12. EMERGENCY RESPONSE PLAN**

The evacuation route and assembly area for Site 13 will be determined by the SHSO. The route and location of the assembly area may change according to operations taking place at the site. The latest route and assembly area shall be mapped and posted in the trailer.

In the event of an accident resulting in physical injury, first aid should be administered and the injured worker transported to the Industrial Medical Clinic (Building 16) for minor emergency or to Alameda Hospital for major emergency treatment. Maps to both locations are attached as Figures C-1 and C-2. The address of the hospital is:

**Alameda Hospital  
2070 Clinton Avenue  
Alameda, CA  
510-523-4357 (Emergency Room)  
510-522-3700 (Hospital)**

To get to the Alameda Hospital, exit the base and turn right onto Main Street, then veer left as the street name changes to Central Avenue. Turn onto Westline Drive, left on Otis Drive, left on Willow, and the hospital is on the left at the next intersection.

The Base Industrial Medical Clinic is located in Building 16 in Alameda, between Third and Fourth Streets. Telephone number is: 510-263-4444.

In the event of a fire or spill, the PS or SHSO should be notified to assess the situation and determine the response. All personnel not trained in spill control cleanup shall evacuate the area. If necessary, the Base Fire Department can be called for fire or emergency response. The ROICC should be notified immediately. Location and type of fire suppression equipment at the project site will be determined later.

**Emergency Telephone Numbers:**

Fire	(Base)	510-263-4300
	(Alameda City)	911 or 510-522-2433
Ambulance		510-263-4444
Police	(Alameda City)	911 or 510-522-2423

**Additional Contingency Telephone Numbers:**

Project Manager:	Fred Porta Phone: 510-652-1164
Program CIH:	Mark Freiberg Phone: 510-643-8676
Project Superintendent:	Jim Gurecki Phone: 510-652-1164
Site Health and Safety Officer:	Judy Cook Phone: 510-531-5377
Occupational Physician:	Lucy Reinke, MD Phone: 510-643-7116
Navy Contact (ROICC)	Wayne Coffey Phone: 510-302-3354
Base Health and Safety Office:	510-263-3395

Navy On-Scene Coordinator (NOSC): 510-263-3276

Navy On-Scene Commander (NOSCDR): 510-263-3003

### **13. GENERAL SAFE WORK PRACTICES**

#### **[Section not included in program-level Health and Safety Plan]**

The project operations shall be performed in accordance with the following minimum safety requirement:

- Eating, drinking, and smoking shall be restricted to a designated clean area.
- All personnel shall wash hands and face before eating, drinking, or smoking.
- Gross decontamination and removal of all disposable personal protective equipment shall be performed prior to exiting the EZ area. Contaminated disposable clothing and other disposable equipment will be removed and collected on-site for disposal. No contaminated equipment will be removed from the site.
- The SHSO shall be responsible to take necessary steps to ensure that employees are protected from physical hazards, which could include:
  - falling objects such as tools or equipment
  - falls from elevations
  - tripping over hoses, pipes, tools, or equipment
  - slipping on wet or oily surfaces
  - insufficient or faulty protective equipment
  - insufficient or faulty operations, equipment, or tools
  - noise
- Field personnel shall be cautioned to inform each other of non-visual effects of the presence of toxins, such as;
  - headaches
  - dizziness
  - nausea

- blurred vision
  - cramps
  - irritation of eyes, skin, or respiratory tract
  - changes in complexion or skin discoloration
  - changes in apparent motor coordination
  - changes in personality or demeanor
  - excessive salivation or changes in pupil response
  - changes in speech ability or pattern
- Field personnel shall be cautioned to observe each other for any of the symptoms of heat or cold stress.

#### **14. DOCUMENTATION**

##### **[Section not included in program-level Health and Safety Plan]**

The Project Manager is responsible for the documentation associated with this SHSP. This documentation shall include all internal and external health and safety correspondence, including this SHSP; all air monitoring data (from the work site and the perimeter areas); all accident reports and Accident Review Board documentation; documentation of audits and corrective actions; air monitoring equipment calibration records; and the FADL forms.

The PS is responsible for conducting and documenting required project-specific training and daily job site safety audits. The PS shall record and document the changes in work zones or note such changes in the FADL.

The SHSO shall record entry and exit times and dates of all personnel and any site visitor(s) who enter the EZ or CRZ. He or she shall also record accidents, incidents of safety infractions by field personnel, and other safety-related matters. The SHSO shall document that monitoring equipment has been properly calibrated and used, and that the results from the monitoring are recorded and filed. The SHSO shall maintain attendance records of tailgate safety meetings and the materials presented in each meeting.

## **SIGN-OFF PAGE**

I have read the Site Health and Safety Plan and fully understand the hazards associated with the activities at Site 13, Naval Air Station, Alameda.

I will comply with the minimum safety requirements set forth in the Site Health and Safety Plan. I agree to notify the responsible employee of BERC should I witness any unsafe acts on this site.

**Print Name**

**Signature**

**Date**

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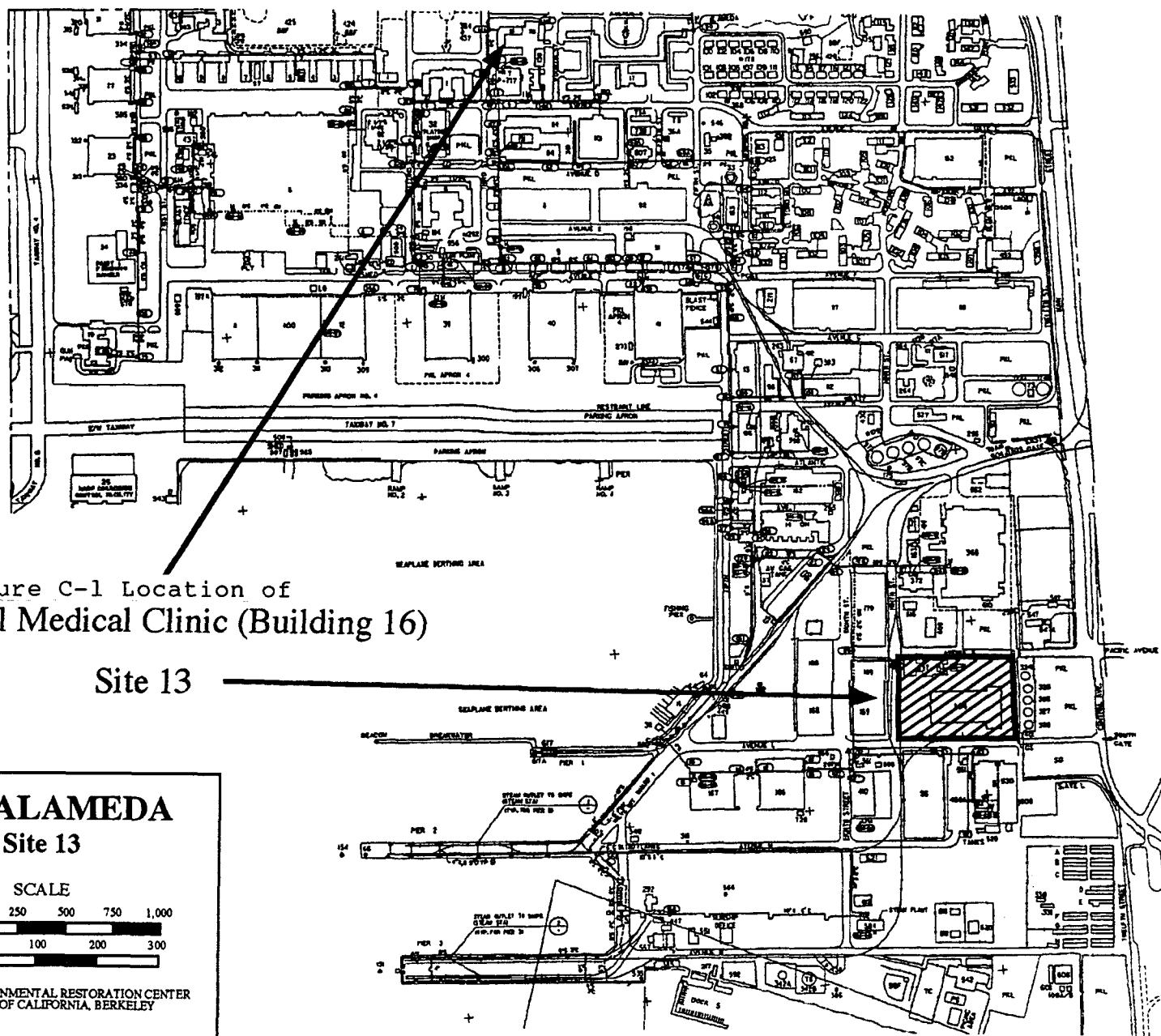


Figure C-1 Location of  
Industrial Medical Clinic (Building 16)

Site 13

**NAS ALAMEDA**

**Site 13**

**SCALE**

0 250 500 750 1,000  
FEET

0 100 200 300  
METERS

BERKELEY ENVIRONMENTAL RESTORATION CENTER  
UNIVERSITY OF CALIFORNIA, BERKELEY



## **APPENDIX D**

# **ENVIRONMENTAL PROTECTION PLAN**

**ENVIRONMENTAL PROTECTION PLAN**

**SITE 13**

**NAVAL AIR STATION, ALAMEDA**

**June 21, 1995**

There are no buildings on this five-acre site, and the surface is mostly fill materials with a sparse presence of grasses and weeds. There does not appear to be any burrows, nests, or scat to indicate the presence of any on-site fauna. According to a PRC employee, no ecological assessment of the site has been completed to date (PRC, 1995). Because this is a demonstration project site, it will be up to the discretion of the EFA-West to restore and/or reseed this area.

Before work activities commence, a standard six-foot cyclone fence will be installed around the perimeter of Site 13 and an exclusionary zone will be identified and marked around the entrance of the site to protect project workers as well as people walking in this area. A 50-foot by 40-foot concrete bermed pad was recently installed adjacent to Avenue L for waste stream treatment and collection from the vapor and liquid extraction system. The steam manifold, which is part of the Steam Enhanced Extraction (SEE) system (a contained system), was also recently installed by the NAS Alameda Department of Public Works directly adjacent to the concrete pad. Additionally, two trailers, supporting the contractor's work force, will be placed within the fenced area.

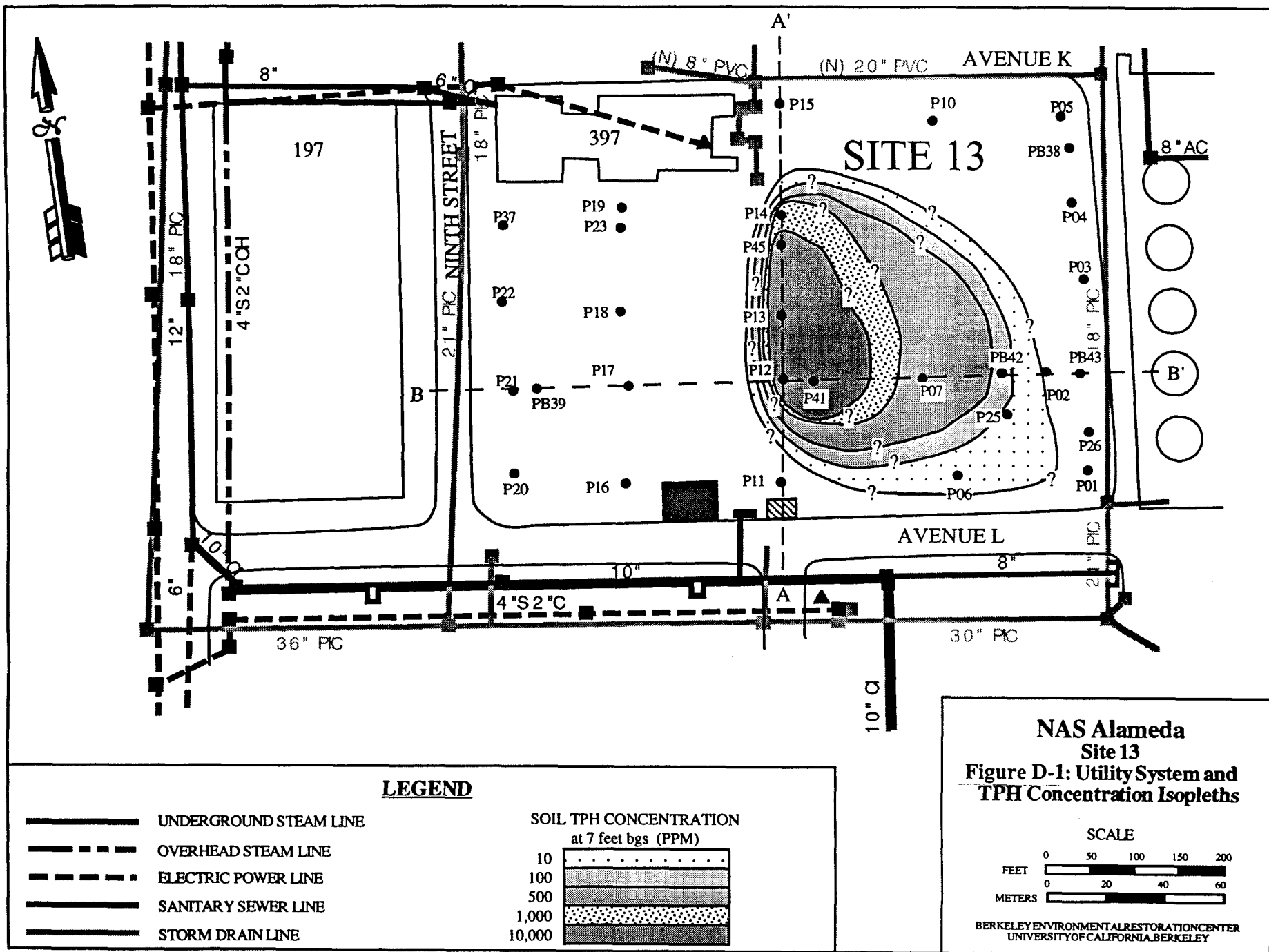
Fugitive dust emissions during grading operations will be controlled by light watering of affected areas as directed by the construction site superintendent or as directed by the Resident Officer In Charge of Construction (ROICC) based upon wind velocity and site observations. The graded surfaces will be covered with two types of surface covering (plastic and corrugated metal) as outlined in the Work Plan. The grading of the test site will provide a sloped surface of one-quarter-inch rise per foot of run for proper drainage of the surface covering. Runoff will be drained via a pipe located in the trench at the base of the surface covering and drained into a sump pump. The runoff will then be pumped periodically at intervals and end up at the waste stream treatment and collection pad. After the injection/extraction wells have been installed, any residual soil from the soil borings will be placed in roll-off bins or drums and covered as necessary.

The locations of known underground utilities at Site 13 (provided by EFA-West) are shown in Figure D-1. A survey to locate all utilities should be conducted before the work commences as it is reported that there is an active water line (PVC pipe) transversing the site. Therefore, any kind of environmental impact from this water line affecting the site condition is premature until all information has been gathered to make an accurate assessment of the situation (ROICC, 1995). The locations of all utilities (steam, electric power line, sanitary, and storm) will be clearly marked with either paint, caution flags, or tape on stakes or temporary

barricades, as appropriate, to the activities at the location and the element of risk. Existing water, sanitary, and storm sewer lines will not be removed or rerouted nor will any associated vaults or drains be removed or interfered with.

The existing above-ground power lines (adjacent to Avenue L) will remain intact, and the contractors will use this power source for the two on-site trailers. Should unanticipated rerouting or removal of utilities be considered necessary during this project, all such activities will proceed only with the knowledge and approval of the ROICC and the Contracting Officer.

The six groundwater monitoring wells at the site will be protected during this pilot-scale treatability study. Each groundwater monitoring well will be completed at the surface with a protective steel casing. Each groundwater monitoring well will be completely sealed with plastic, or a corrugated metal cover will be placed over the well head. Each location will be marked with grade stakes and caution flags.



**NAS Alameda  
Site 13  
Figure D-1: Utility System and  
TPH Concentration Isopleths**

## **APPENDIX E**

### **STEAM ENHANCED EXTRACTION PROCESS - P & ID**



UNIVERSITY of CALIFORNIA

Berkeley Environmental  
Restoration Center  
2000A Etcheverry Hall  
#1750 Berkeley, Ca 94720

PROJECT

SHEET TITLE

STEAM  
ENHANCED  
EXTRACTION  
PROCESS -  
PI & D

ENGINEERS, INC.  
28005 Piedmont Street, Hayward, Ca 94545  
Phone: 510-882-1280 Fax: 510-882-4753

REVISIONS

NO. DESCRIPTION

PROJECT NO.

DATE

6-22-1995

CODE

SHEET

2

FILE

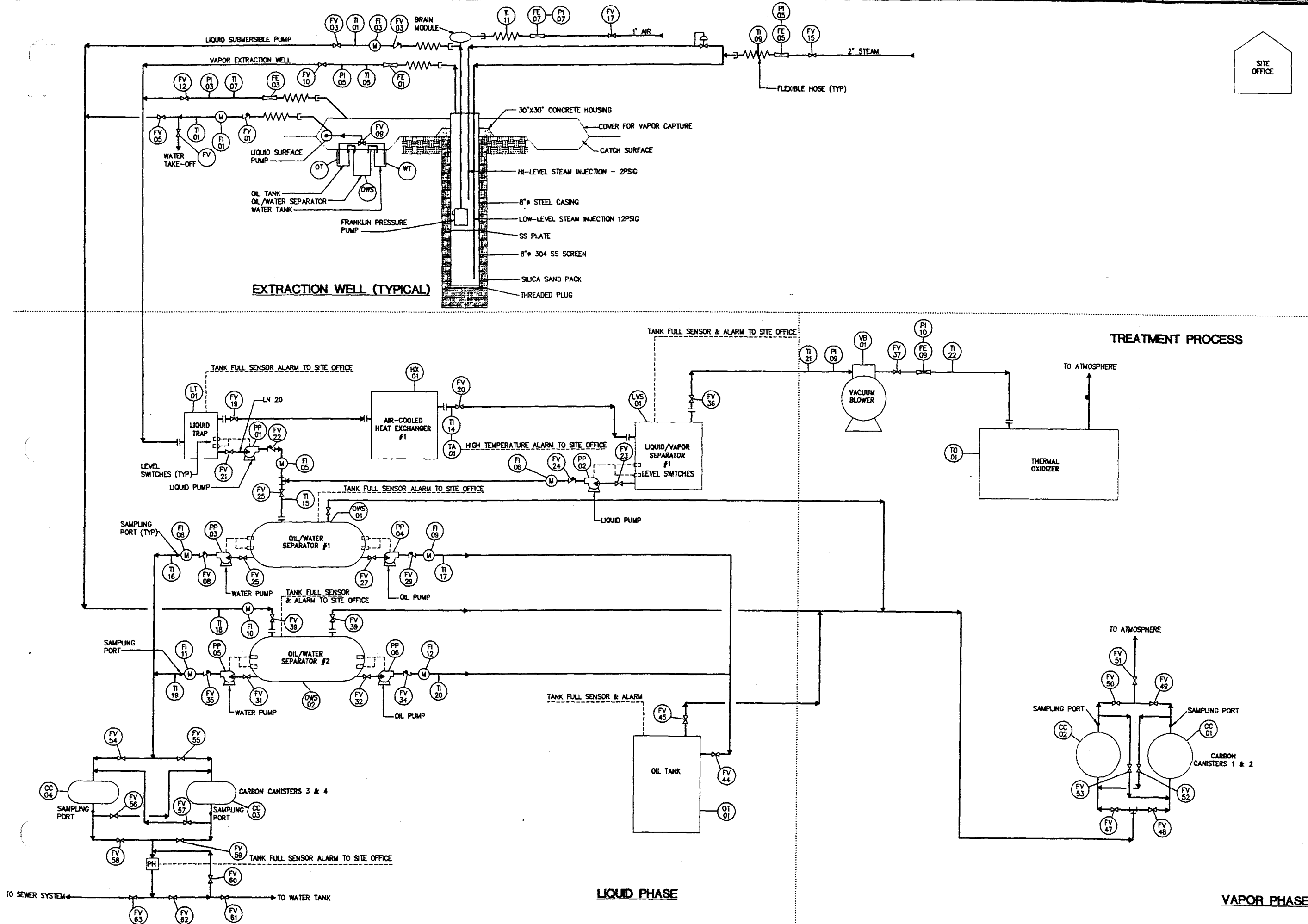
SITE OFFICE

EXTRACTION WELL (TYPICAL)

TREATMENT PROCESS

LIQUID PHASE

VAPOR PHASE



## **APPENDIX F**

### **SUPPLEMENTAL INFORMATION**

**AN ANALYSIS OF OPTIMAL CYCLING TIME AND ULTIMATE  
CHLORINATED HYDROCARBON REMOVAL FROM HETEROGENEOUS  
MEDIA USING CYCLIC STEAM INJECTION**

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**Abstract**

A numerical and theoretical study of chlorinated hydrocarbon removal from porous media using cyclic steam injection is presented. The porous medium modeled is a high permeability fracture, adjacent to a thick, contaminated low permeability zone. Two-dimensional computer simulations were run for different initial saturations of TCE and PCE until aqueous phase concentration levels were below 1 ppb ( $\mu\text{g/kg}$ ). The two-dimensional simulations provided interesting details of the steam-water contaminant redistribution and volatilization rates during various steam cycling modes. To generalize the results of numerical simulations, theory is developed to estimate optimal cycle times and the effectiveness of cyclic steam injection in reducing aqueous concentrations to drinking water standards. The analytic predictions of optimal cycle times and ultimate rates of contaminant concentration reduction compared well with those of the numerical simulations.

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## Nomenclature

$C$	concentration [ $\text{kg/m}^3$ ]
$c_p$	constant-pressure specific heat [ $\text{J/kg-K}$ ]
$Fo$	Fourier Number [ ]
$H$	Henry's constant [ $\text{Pa-m}^3/\text{kg}$ ]
$\bar{H}$	dimensionless Henry's constant [ ]
$h_{fg}$	heat of vaporization [ $\text{J/kg}$ ]
$k$	permeability [ $\text{m}^2$ ]
$k_r$	relative permeability [ ]
$m$	mass [ $\text{kg}$ ]
$P$	pressure [ $\text{Pa}$ ]
$R$	gas constant [ $\text{J/kg-K}$ ]
$s_w$	water saturation [ ]
$T$	temperature [ $\text{K}$ ]
$t$	time [ $\text{sec}$ ]
$X$	mass fraction [ ]
$\phi$	porosity [ ]
$\Gamma$	mass fraction ratio of $i$ in water phase to $i$ in vapor phase [ ]
$\lambda$	root to fourier series [ ]
$\lambda_{\text{eff}}$	effective thermal conductivity [ $\text{J/m-K}$ ]
$\mu$	dynamic viscosity [ $\text{N-sec/m}^2$ ]
$\rho$	density [ $\text{kg/m}^3$ ]
Subscripts	
$i$	contaminant $i$
$o$	original state
$s$	surface
$v$	vapor phase
$w$	water phase
$\infty$	at infinite time

## Introduction

Conventional methods used for cleaning up *in situ* subsurface spills of Dense Non-Aqueous Phase Liquids (DNAPL's) include vacuum extraction for the vadose zone and ground water pumping for regions below the water table. Unfortunately, these conventional technologies tend to become ineffective for contaminants not found in pumped fluid flow paths leading to the extraction wells. Since many DNAPL's are only minimally soluble in water and the aqueous phase molecular diffusivities are so low, immobile DNAPL's located below the water table and in large low permeability zones are almost impossible to remove within a lifetime. Since their paths of downward migration of DNAPL's are usually different than the fractures supporting fluid flow during pumping, DNAPL contamination of fractured bedrock or clay is a particularly problematic situation. The technology of steam enhanced extraction [1], where steam is injected into the subsurface to heat the contaminated regions and either evaporate or displace separate phase contaminants, offers hope that such environmental hazards can finally be cleaned up.

## Background

Steam enhanced extraction with cyclic steam injection for use in removing volatile and semi-volatile contaminants from the subsurface has been applied to two field sites. The first was conducted on a pilot scale in San Jose in the summer of 1988. After a period of 140 hours of constant-rate steam injection, a series of vacuum extraction and steam injection periods followed. The depressurization periods were on the order of only one to three hours in duration but showed promise as a method of removing contaminants from heated low permeability regions [2].

At the Lawrence Livermore National Laboratory, steam enhanced extraction was used at full-scale to clean-up a gasoline spill. There were two high permeability zones, one above and the other below the water table. Steam was injected in two different passes. The first steam injection period lasted 35 days. At the end of the first steam pass, recovery

rates were averaging 45 gallons per day. Three months later, after a higher capacity effluent waste treatment system had been installed, recovery rates increased to over 200 gallons per day. Two weeks into the second pass of steam injection, with the recovery rates having dropped to 80 gallons per day, steam was turned off while a vacuum was still pulled at the extraction well. The recovery rate peaked at 130 gallons per day two days later and then dropped to 110 gallons per day two days after that. When steam was turned on again at this point, recovery rates dropped off to 50 gallons per day. This cycling of steam on and off was done one more time with similar results [3].

The mechanisms for the removal of a DNAPL in a porous media using steam injection/vacuum extraction have been identified as a piston-like displacement of liquids and a thermally enhanced evaporation/advection mechanisms [4,5]. Cyclic steam injection after steam breakthrough introduces another mechanism; *in situ* boiling of heated liquids in and around the steam zone [1]. This third mechanism is important should there be significant permeability differences in the layers composing the contaminated region. In both laboratory experiments and field studies, steam has been found to preferentially enter the high permeability regions, initially bypassing contaminated low permeability zones. Thicker low-permeability regions take a longer time for the steam to heat, thus increasing the time necessary for steam injection to clean out the contaminants [2,3,6,7]. Similarly, for a fractured bedrock system, steam should be able to remove contaminants from accessible fractures relatively quickly. However, once sufficient time has passed for conduction to heat the low permeability zones, depressurization provides a means to remove contaminants from the inaccessible fractures and the adjacent bulk bedrock.

A schematic of a typical situation encountered during the latter stages of steam enhanced extraction operations is shown in Figure 1. Here the liquid contaminant has been removed from the high permeability zones above and below the contaminated low permeability layer. Conductive heat transfer, augmented by some enthalpy flux carried with any steam that might flow into the low permeability zone, will eventually heat the layer

to temperatures near those of the adjacent high permeability zones. During this time, compounds with boiling points lower than that of water will boil from the medium, leaving residual contamination in the aqueous phase and adsorbed to the solid surfaces. For negligible fluid flow through the low permeability region, recovery would be limited by diffusion. DNAPLs' with boiling points greater than that of water will be particularly difficult to remove since the mass transfer rates would remain low and the residual liquid contaminant mass remains high. However, cyclic steam injection following steam breakthrough increases recovery rates since liquid water and separate phase contaminant will boil when the system is de-pressurized. The energy required for the phase change comes from the solid matrix and liquid during the cooling associated with the de-pressurization of the steam-water system. Consider the thermodynamics involved in bringing an otherwise closed reservoir system from steam conditions (115°C) to that of a 50 kPa vacuum. The temperature corresponding to the equilibrium vapor pressure of water at a 50 kPa vacuum is 82°C. If the reservoir temperature is at 115°C when the 50 kPa vacuum is applied, then a 33°C temperature drop must occur before a uniform pressure distribution can be established. Depending of the heat capacity of the solid matrix material, the porosity and the water volumetric fraction of the pore space, about 10% of the liquid water present must evaporate to satisfy the energy and mass balances. This evaporation will continue to occur uniformly until the temperature of the reservoir has dropped to 82°C, cooler if any air is present. A large pressure gradient caused by the evaporation can form in the lower permeability zones which can drive out mobile liquid water and contaminant from otherwise inaccessible zones into the higher permeability zones leading to extraction wells. After the system has been de-pressurized and partially de-watered, steam injected in latter cycles will clear out contaminant that had migrated into the higher permeability zones, and re-charge the energy released during the previous depressurization cycle. The decrease in the water saturation resulting from de-pressurization also increases the steam permeability,



providing for a more effective heating of the lower permeability zones during subsequent steam injection cycles.

### **Numerical Simulation**

Simulations of the effectiveness of constant rate steam injection and cyclic injection were carried out using a coupled air-water heat and mass transfer computer code originally developed by Preuss [8], and extended to non-isothermal transport of multiple component liquid contaminants by Adenekan and Patzek [9]. The code structure was further modified to improve robustness and allow simulations using various computational platforms. The code can model three-dimensional multi-phase transport of multi-component organic contaminants in the subsurface in response to constant or cyclic steam injection.

Simulations were run for two different contaminants and with two different initial saturations. Both TCE and PCE simulations were run at uniform initial saturations of 30% and 85%. The simulations were run until the remaining hydrocarbon concentrations were less than  $10^{-10}$  of the initial concentration.

The system considered was a two-dimensional region, 40 cm wide, and 80.2 cm high, divided into 68 control volumes (see Figure 2). The control volumes of the top row were 0.2 cm high and 10 cm wide and the node control volumes in the lower sixteen rows were 5 cm high and 10 cm wide. The permeability of the top row of nodes, roughly corresponding to a fracture, was  $45 \times 10^{-12} \text{ m}^2$  and the bulk permeability of the lower rows of nodes was  $0.35 \times 10^{-12} \text{ m}^2$ . The permeability was isotropic within each grid block. The left-most block of the high permeability zone contained the injection well and the right-most high permeability node contained the extraction well. All other boundaries were closed and treated as adiabatic (perfectly insulated). The steam injected at the injection node was held at 103°C, 115 kPa, and 90% quality. The extraction well was maintained at a 61 kPa vacuum. Gravity was neglected for these simulations.

The computed NAPL saturation, temperature, and water saturation fields are plotted in Figures 3-5. The white color in the NAPL saturations represent zero saturation and the

light gray in the zero time image represents the initial 30% TCE saturation. As the steam enters the system, a region cleared of TCE develops in the upper right corner and progresses downward. Ahead of the clean zone, a band of high saturation of TCE develops. The maximum saturation in this band varies with time from 70% to 85%. At 50 hours, the high saturation band has propagated to the far end of the system. At this point in time, the steam is migrating into the lower permeability region, evaporating the TCE, and carrying it out to the extraction face.

The temperature plots are very similar in shape to the concentration plots. The region that has been cleared of TCE is the hottest. There is a sharp temperature gradient, corresponding to the steam condensation front, in the region that is occupied by the maximum TCE saturation wave in the system. The water saturation plots clearly show that water saturation maxima is located at the steam condensation front.

The TCE saturation at three different nodes is shown in Figure 6. The nodes are labeled A, B, and C in Figure 2. For Node A, located in a low permeability zone two rows from the high permeability nodes, the NAPL-phase saturation drops to zero within the first hour of the simulation. For Node B, located in the middle of the low permeability zone, the NAPL-phase saturation rises quickly to 83% at two hours after the start of steam injection and then drops to zero over the next 6 hours. For Node C, found at the bottom of the low permeability zone, the TCE remains at the initial 30% saturation for almost 15 hours before rising to a maximum saturation of 78% at 27 hours. The TCE is slowly removed after that; the separate phase TCE finally evaporating at the 76 hour mark.

The temperature profiles for those same three nodes are shown in Figure 7. As expected, the temperature of Node A changes almost immediately to that of saturated steam. The temperature of the Node B rises to 88°C after the separate phase TCE completely evaporates from that node. The small oscillations in the temperature histories are due to numerical instabilities encountered when the rows of nodes surrounding that particular node experience a high rate of TCE evaporation. The temperature of Node C increases to

near 70°C after 28 hours and remains constant for almost 50 hours. It levels off at 70°C because the pressure at that node corresponds to the vapor pressure of TCE at 70°C. After the liquid TCE is gone from the node, the temperature of that node finally begins to rise again. The temperature of the bottom node does not reach 96°C until the adjacent bottom row nodes are void of liquid TCE.

Figure 8 shows the water saturation for Nodes A, B, and C. Node A maintains an almost uniform water saturation of 13% throughout the simulation. The water saturation for Node B varies significantly with time. The oscillation at early time seems to be a numerical artifact of the rapidly changing NAPL phase at those times. As the steam front passes node B, the saturation maintains a steady 30% until dropping to near 13% as the NAPL phase completely disappears in the far end of the system. Node C maintains the initial water saturation of 10% for most of the simulation, only dropping a few percent when the steam front approached the node.

### Cyclic Steaming

For an initial saturation of 30% TCE, 60% air, and 10% water, removal of 99% of the initial TCE was predicted by continuous steam injection in 96 hours. Subsequent predictions of cyclic steaming were begun at 22 hours after the start of steam injection. To accomplish this using the simulator, the source term for the steam was removed but the vacuum at the extraction node was maintained. The amount of TCE remaining in the system is plotted in Figure 9 for continuous steam injection and for three different cycle times. At the start of the first vacuum cycle, the TCE recovery rate, shown in Figure 10, immediately rose by a factor of 3.5 over the next hour. At ten hours into this vacuum cycle, the recovery rates had dropped back down to the level that it was just before the start of the vacuum cycle. After 22 hours of vacuum, the recovery rates had dropped to 1/3 of the rate of the continuous steam case at that time, but the total TCE mass removed up to that point was 78% versus 70% for continuous steam. At the end of this vacuum cycle, the

system temperature was almost uniformly 50°C. Once steam was re-injected after 44 hours, the recovery rates initially dropped off to zero. At this time, most of the steam was going into re-heating and repressurizing the system. Four hours after the re-start of steam injection, the TCE recovery rates began to increase rapidly; approaching the rates that were seen during the steam only run. The second 22-hour vacuum cycle removed all of the remaining separate phase TCE. The average temperature of the system after the second vacuum cycle was 63°C. Compared with the steam only case, it took 98% of total clean-up time but only 58% of steam injection time. The Fourier number (equation 6) for a 22 hour cycle is 3.64.

When shorter 10 hour ( $Fo = 1.65$ ) and 6 hour ( $Fo = 0.99$ ) cycle times were simulated, the total clean-up time was reduced considerably. As before, the steam/vacuum cycling began after the initial 22 hours of continuous steam simulation. For the 10 hour cycle time, the separate phase TCE was removed at 65 hours -- using only 68% of the total time used by steam only and 44% of the steam time used by the 22 hour cycle case. Using the cycle time of 6 hours, the savings are just a little bit better -- shaving an additional 9 hours off the total time and 6 hours off the steam time required for clean-up to 1 part per billion.

The NAPL saturation, temperature, and water saturations during the first three hours of vacuum extraction and then the first three hours of the re-start of steam injection for a 10 hour cycle time are plotted in Figures 11-13. In Figure 11a, the start of vacuum extraction (22 hours), the TCE spreads from the bottom of the system out towards the extraction well. When steam is injected again (32 hours) as shown in Figure 11b, the remaining separate phase TCE is partially pushed back into the system. There is however, a noticeable decrease in the overall saturation between the system at the start of the vacuum cycle and three hours into the next steam injection cycle (35 hours).

Figure 12 shows how quickly the temperature in the system comes to equilibrium as the steam is turned off and then on again. At 25 hours, the temperature of the system is

almost uniform and at 35 hours, the temperature field is almost identical to the one at 22 hours. The water saturations show a similar pattern to that of the TCE concentrations in that the saturation wave is removed during the first few hours of vacuum extraction and it re-forms during the first few hours of steam injection.

The TCE phase saturations for the 10 hour cycle time at the three nodes discussed earlier are plotted in Figure 14. The big difference between the cycle phase saturations and those of Figure 6 is that the saturation only peaks at 50% (vs. 78%) and is removed completely at 68 hours instead of 76 hours. The dip in the TCE saturation caused by the vacuum extraction is easily seen at the 22, 42, and 62 hour times at Node C. The temperature of the three nodes are plotted in Figure 15. The temperatures for Nodes A and B drop quickly when vacuum extraction begins and rise when steam injection begins again. The temperature maxima are fairly constant but the minimum temperature at the end of the vacuum cycles rise during each successive cycle. Node C takes much longer to get rise to steam temperatures but this is expected as the presence of the highly volatile liquid TCE remains at that node until the third vacuum cycle. After this time, the temperature at that node rises to nearly 100°C during the following steam injection period.

Additional computer runs were performed for an initial concentration of TCE of 85%. Similar results were achieved compared with the earlier series of TCE runs. Since the amount of TCE in the system was much higher, it is not surprising that the total time for removal of separate phase TCE took 180 hours. This time, a cycle time of 22 hours saved 50 hours of total clean-up time and 55 hours of steam time. Savings of even more time was achieved when a cycle time of 10 hours was used.

PCE, which has a boiling temperature of 121°C takes much longer to remove than the more volatile TCE. For 30% initial concentration of contaminant, the simulations predicted 162 hours to remove 99% of the PCE and 184 hours to reduce residual contamination levels to the 1 ppb level. Using a 44-hour cycle time, the time to remove 99% of the PCE increased to 195 hours and the time to the 1 ppb level increased to 221

hours but there still was a savings of 52 hours of total steam time over continuous steam. Table 1 shows the relative economics for all four systems and cycle times considered.

### Theoretical Analysis of Optimal Cycle Time

The thermodynamics of cyclic steam injection can be easily modeled in a one-dimensional framework. Of interest here are the optimal cycle time and the rates at which the contaminant can be removed by cyclical depressurization. The time scale for evaporation or condensation process to occur can be estimated from the coupling of the flow and energy transport equations[10]. Starting with Darcy's Law

$$\dot{m}_v = -\rho_v \frac{kk_{rv}}{\mu_v} \frac{\partial P}{\partial x}, \quad (1)$$

an energy balance,

$$\frac{\partial}{\partial x} \left( \lambda \frac{\partial T}{\partial x} \right) - \frac{\partial}{\partial x} (\dot{m}_v h_v) = \rho c_p \frac{\partial T}{\partial t} \quad (2)$$

and the Clayperon equation to relate the saturation temperature gradient to a pressure gradient,

$$\left. \frac{\partial P}{\partial T} \right|_{sat} = \frac{\rho_s h_{fs}}{T} \quad (3)$$

a relationship for the energy balance can be written as:

$$\frac{\partial}{\partial x} \left( \lambda_{eff} \frac{\partial T}{\partial x} \right) = \rho c_p \frac{\partial T}{\partial t} \quad (4)$$

where the effective thermal conductivity of the system [11] is

$$\lambda_{eff} = \lambda + \frac{kk_{rv}}{\mu_s T} \rho_s^2 h_{fs}^2 \quad (5)$$

If the effective thermal conductivity is assumed to remain constant during the pressurization or de-pressurization processes, then equation (4) is the familiar Fourier equation. Although evaporation or condensation can change the water content, thus altering the relative permeability, the assumption of a constant effective thermal

conductivity is reasonable for small (<10%) changes in water mass or temperature (<30°C).

We model our system as a one-dimensional slab with a step change in surface temperature corresponding to a step change in the imposed pressure, with a no-flux condition at the low permeability zone centerline at  $L$ . Analytical solutions to this problem are available in the literature [12], and have been graphically presented by Heisler [13]. The temperature at the middle of the slab is:

$$\frac{T - T_s(P)}{T_o - T_s(P)} = 2 \sum_{n=0}^{\infty} \frac{(-1)^n}{\lambda_n} e^{-\lambda_n^2 Fo} \quad (6)$$

where  $\lambda_n = (2n+1)\pi/2$ ,  $Fo = \alpha t/L^2$ , and  $\alpha = \frac{\lambda_{eff}}{\rho C_p}$ .

The time necessary for the temperature of the center of the slab to change to 90% of the difference between the initial temperature and the surface temperature is obtained from a value of the Fourier Number equal to 1. From this condition, we approximate the optimal steam/vacuum cycle time. The optimal cycle time for different bulk permeabilities and for different layer thicknesses is plotted in Figure 16. For permeabilities less than  $1 \times 10^{-15} \text{ m}^2$  (1 mDarcy), the effective thermal diffusivity  $\lambda_{eff}$ , approaches the actual thermal diffusivity  $\lambda$  since the vapor flow becomes insignificant even with large pressure gradients.

### Theoretical Analysis of Ultimate Cleanup Levels

The very rapid drop in contaminant mass predicted by the simulations during the depressurization cycle after the separate phase had been removed is of great interest since the goal of drinking water standard concentrations are very quickly met. The potentially high residual concentration of contaminants in aqueous phase is of concern since the boiling of volatile contaminants is likely to increase contaminant contact with water and leave the water with concentration near the solubility limit. This residual concentration might leave the site with long-term pumping needs if not removed as a part of the

processing. From the simulations, it appears that depressurization provides a mechanism for removing *in situ* dissolved phase contaminants to drinking water standards. To support that observation, an equilibrium model of the contaminant removal rate during depressurization is developed.

To determine the rate at which dissolved water phase contaminant  $i$  can be removed from liquid water, we begin with a partially saturated porous media at steam temperature. The total mass of  $i$  present in the system is equal to the mass of water times the mass fraction of  $i$  in the water phase ( $X_i$ ).

$$m_i = m_w X_{i,w} \quad (7)$$

The change in the mass of  $i$  in the system can be found by taking the derivative of equation 7. This change in the total mass of  $i$  is also equal to the mass fraction of  $i$  in the vaporized water multiplied by the rate of water evaporation.

$$\frac{d}{dt}m_i = \frac{d}{dt}(m_w X_{i,w}) = X_{i,vap} \frac{d}{dt}m_w \quad (8)$$

We relate the concentration of  $i$  in the vapor phase to that in the liquid phase through the linear relationship of Henry's law. A common representation of Henry's law is:

$$P_{i,v} = H C_{i,w} \quad (9)$$

where  $P_{i,v}$  is the partial pressure of contaminant  $i$  in the vapor phase,  $C_{i,w}$  is the concentration of  $i$  in the water phase, and  $H$  is the Henry's constant.

Re-writing Equation 9 in terms of a non-dimensional Henry's Law we arrive at:

$$X_{i,v} \rho_v = \bar{H} X_{i,w} \rho_w \quad (10)$$

where  $\bar{H}$  is the non-dimensional Henry's Law constant which is equal to the ratio of the mass concentration of  $i$  in the vapor phase to the mass concentration of  $i$  in the water phase. Equation 10 can be transformed into Equation 11 where the dimensionless Henry's



constant has been replaced by  $\Gamma$  ( $\Gamma = \rho_v/\rho_w \bar{H}$ ) which is the ratio between the mass fraction of  $i$  in the water phase to the mass fraction of  $i$  in the vapor phase.

$$X_{i,w} = \Gamma X_{i,v} \quad (11)$$

Substituting Equation 11 into Equation 8 and re-arranging terms yields:

$$\left( \frac{1-\Gamma}{\Gamma} \right) X_{i,w} \frac{d}{dt} m_w = m_w \frac{d}{dt} X_{i,w} \quad (12)$$

For a given pressure drop, only a certain fraction of the mass of water will evaporate due to thermodynamic limitations. From the analytic expression for the temperature at the center of the slab (Equation 6), an exponential decay of  $m_w$  from the initial water mass,  $m_{w0}$ , to the final water mass,  $m_{w\infty}$  is expected. The mass remaining, to leading terms in the Fourier series of Equation 6, is given by

$$m_w = m_{w\infty} + (m_{w0} - m_{w\infty}) e^{-\frac{\pi^2 Fo}{4}} \quad (13)$$

The solution to Equation 12 is:

$$\frac{C_{i,w}}{C_{i,w0}} = \left( \frac{1 + \left( \frac{m_{w0} - m_{w\infty}}{m_{w\infty}} \right) e^{-\frac{\pi^2 Fo}{4}}}{1 + \left( \frac{m_{w0} - m_{w\infty}}{m_{w\infty}} \right)} \right)^{\left( \frac{1-\Gamma}{\Gamma} \right)} \quad (14)$$

This equation is plotted in Figure 17 for various values of the dimensionless mass fraction ratio  $\Gamma$ , the water mass fraction removed,  $(m_{w0} - m_{w\infty})/m_{w0}$ , and the Fourier Number.

At large time, when most of the evaporation has taken place, the concentration in the water phase reduces to:

$$\frac{C_{i,w\infty}}{C_{i,w0}} = \left( \frac{m_{w\infty}}{m_{w0}} \right)^{\left( \frac{1-\Gamma}{\Gamma} \right)} \quad (15)$$

Equation 15 is plotted in Figure 18 for different values of  $\Gamma$  and mass fraction removed. As shown in Figure 18, aqueous phase TCE concentrations can change by orders of magnitude for even small amounts of water evaporation. This is due to the large exponential provided by  $(1-\Gamma)/\Gamma$ . For TCE,  $\Gamma$  would be approximately 0.003 at 20°C, and decreases with an increase in temperature since the vapor pressure of TCE rises more quickly with temperature than its solubility in water. For a value of  $\Gamma$  of 0.002, a 1% reduction of water mass by evaporation will cause a drop of two orders of magnitude in aqueous contaminant concentration. Removal of 2% and 5% of the water will drop TCE concentrations by five and twelve orders of magnitudes respectively. Limitations in flow paths for water vapor to leave lower permeability regions may prevent concentration levels from dropping as fast as is theoretically possible. However, the expectation that the boiling process occurs on the pore level in a manner determined by the local heat transfer from solid particles to the water vapor interface gives rise to the hope that, once separate phase contaminants have been removed, concentration levels can be reduced to drinking water standards very quickly.

The value of  $\Gamma$  for several different chemicals at 20 °C are listed in table 2. Also listed in the table are the mass fraction of the contaminant in the water and in the liquid phase. Reasonable large values of the mass fraction of the contaminant in the vapor phase are realized for many of the contaminants because, even though the vapor pressures are small relative to the total pressure, the large difference in the molecular weight of the contaminant molecules compared with that of the water vapor molecules or the oxygen and nitrogen molecules in the air. Combining this effect with the low solubility of many of the contaminants in water leads to the low values of  $\Gamma$  which range from a low of 0.0011 for PCE to a high of 0.024 for Dichloromethane.

The temperature effect on  $\Gamma$  for common contaminants cannot be explored without additional data on the temperature dependence on their solubility in water. Clearly the vapor pressures for all of the chemicals will rise with increasing temperatures but it is the behavior of the solubility of the contaminant in water that will determine the magnitude of  $\Gamma$  at high temperatures. Since, for many of the chemicals listed in Table 2, the mass fraction of the contaminant in the vapor phase is already significant (over 25%), a rise in the vapor pressure can only increase the mass fraction by a factor of four, whereas there is a much smaller limitation on the growth of the mass fraction in the liquid phase with an increase in temperature.

The limiting conditions for  $\Gamma$  in Equation 15 are  $\Gamma = 0$  (corresponding to a substance that is soluble in water but with a negligible vapor pressure) and  $\Gamma = \infty$  (corresponding to a substance with a non-negligible vapor pressure but is nearly insoluble in water). For the case of when  $\Gamma$  approaches 0, we expect that the contaminant concentration should increase inversely proportional to the amount of water removed. Equation 15 is reduced to  $C_{i,\infty}/C_{i,0} = m_{i,0}/m_{i,\infty}$ . For the second limiting condition of  $\Gamma = \infty$ , in which all of the contaminant mass should be driven off immediately, Equation 15 becomes  $C_{i,\infty}/C_{i,0} = (m_{i,\infty}/m_{i,0})^{-\infty}$ , which means that evaporating a little water will drive off the remaining contaminant in solution. For the case that the contaminant behaves exactly like the water ( $\Gamma = 1$ ), Equation 15 reduces to the trivial solution of  $C_{i,\infty} = C_{i,0}$  or the concentration remains constant.

The amount of water that will evaporate in the porous media as a result of a pressure change can be solved using the Clapeyron equation combined with energy balances resulting in the following relationship for the fraction of water mass removed.

$$\frac{\Delta m}{m_o} = \frac{T^2 R}{\rho_w s \phi h_{fg}^2} \left[ (1 - \phi) \rho_w C_p + \phi s_w \rho_w C_p \right] \ln \left( \frac{P_1}{P_0} \right) \quad (15)$$

where  $R$  is the gas constant,  $P_0$  and  $P_1$  are the final and the initial pressures and  $T$  is taken at steam temperatures. This equation is plotted in Figure 19 for two values of porosity and

different values of water saturation for a depressurization from some absolute pressure to a final pressure of 50,000 Pa absolute (0.5 atmosphere vacuum). The curves are not straight since, as the temperature and pressure drops, the rate of change in the temperature decreases slower than the rate of change of the pressure. As can be seen, in a system with 40% porosity, a change of pressure of 1.5 atmospheres to 0.5 atmosphere can result in a loss of at least 10% of water mass in a system. For the 30% initial TCE simulation run, a vacuum extraction cycle pulled out 20% of the water in the system.

## **Discussion**

Using the Fourier number equal to 1 to estimate the optimal steam/vacuum cycle time, we found a time of 6 hours for the conditions of the system. This would correspond approximately to the time required for the effluent rates to begin to drop off after the initial high rates following the start of steam injection. For the 30% TCE case presented, a cycle time of 6 hours was superior compared with the larger cycle times or with constant steaming. The simulations predicted only a few cycles to completely remove the contaminant from the system so it is impossible to pinpoint the optimal Fourier Number for quickest clean-up.

For the Lawrence Livermore National Laboratory site, the corresponding optimal cycle time would have been 10 days. This is based on a 6 meter thick low permeability zone and the thermal properties of the soil to be those of sand. The LLNL site was operated with a cycle time of 5 days. It may be that a larger cycle time would have resulted in a greater quantity of gasoline recovered within the operational time limits of the second steam pass where cyclic steam was effectively applied. More field data are needed to fully investigate the optimal cycle time in a real heterogeneous system.

## **Conclusions**

Steam enhanced extraction using cyclic steam injection after steam breakthrough of a simple two-dimensional numerical system was presented. In the simulation, both TCE and PCE, located initially in a low permeability region were effectively removed. Cyclic

steam injection always shortened the total steam injection time although the total time for clean-up varied depending on time chosen for the steam cycling. A modified Fourier Number of 1 gave a good estimate of the optimal cycle time for the numerical system and a reasonable estimate of the actual operation at the Lawrence Livermore Laboratory field site.

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3. Udell, Kent S, "Thermally Enhanced Removal of Liquid Hydrocarbon from Soils and Groundwater", Chapter in *Subsurface Restoration*, C. H. Ward Ed. In Press
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8. Preuss, K. "TOUGH2 -- A general-purpose numerical simulator for multi-phase fluid and heat flow", Lawrence Berkeley Laboratory Report No. LBL-29400, September 1990.
9. Adenekan, A. E., Patzek, T. W. and Preuss, K., "Modeling of Multiphase Transport of Multi-component Organic Contaminants and Heat in the Subsurface: Numerical Model Formulation" *Water Resources Research*, Vol 29. No 11, pp 3727-3740.
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11. Udell, K. S., "Heat transfer in porous media considering phase change and capillarity -- the heat pipe effect", *International Journal of Heat and Mass Transfer*, Vol 28 pp 485-495, 1985.
12. Arpaci, Vedat S, *Conduction Heat Transfer*, Addison-Wesley Publishing Company, 1966.

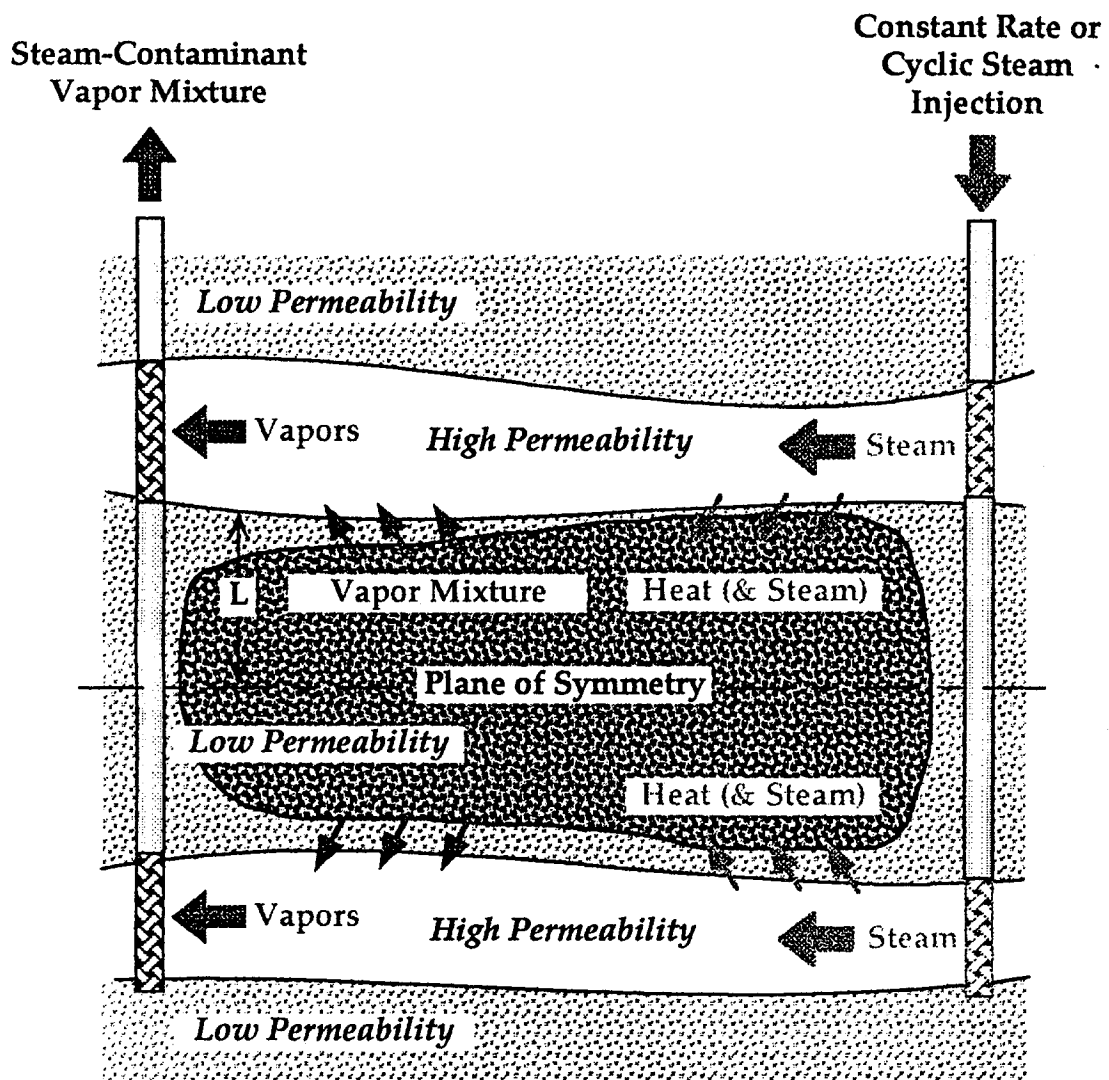


Figure 1 Schematic of volatile contaminant removal from a low permeability region bounded on two sides by high permeability zones.

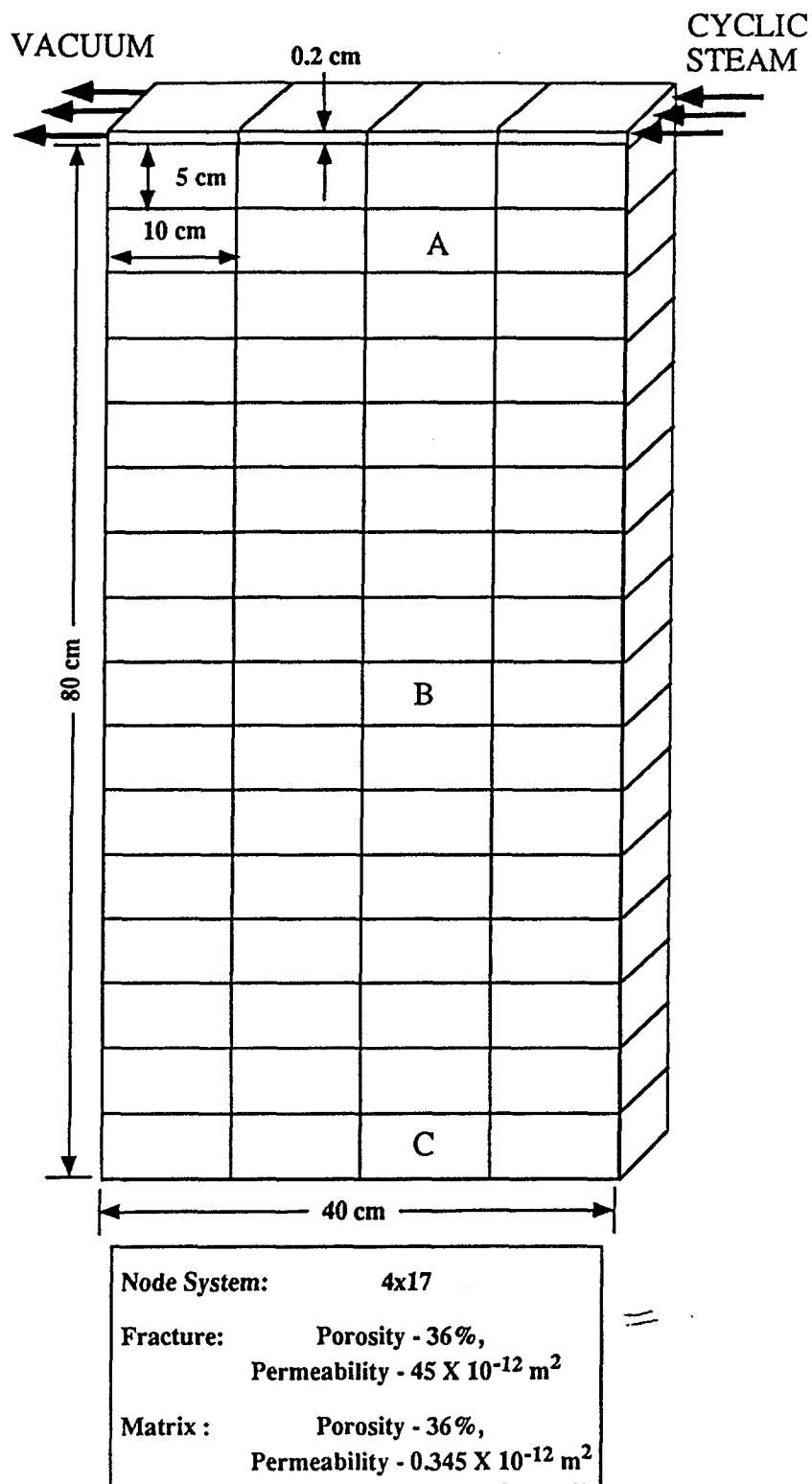
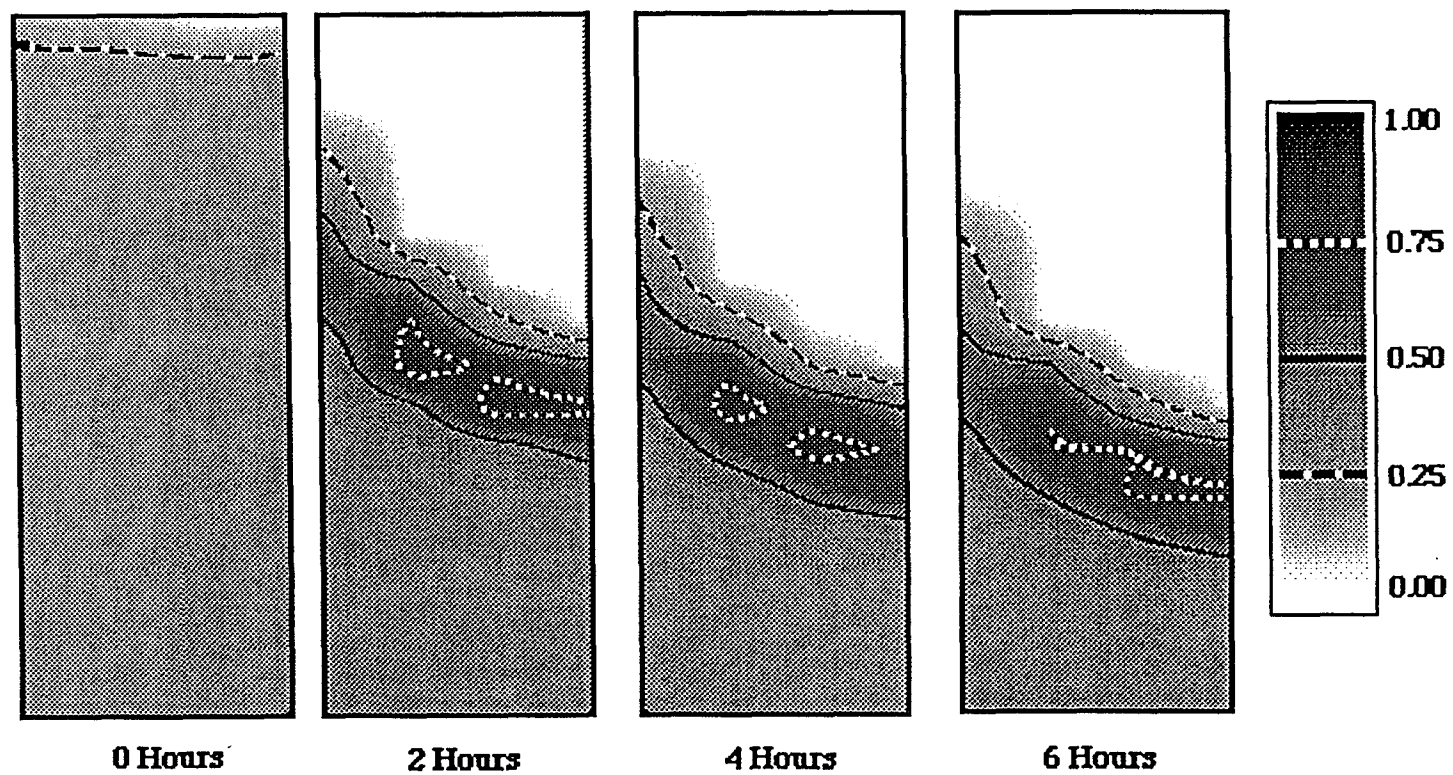


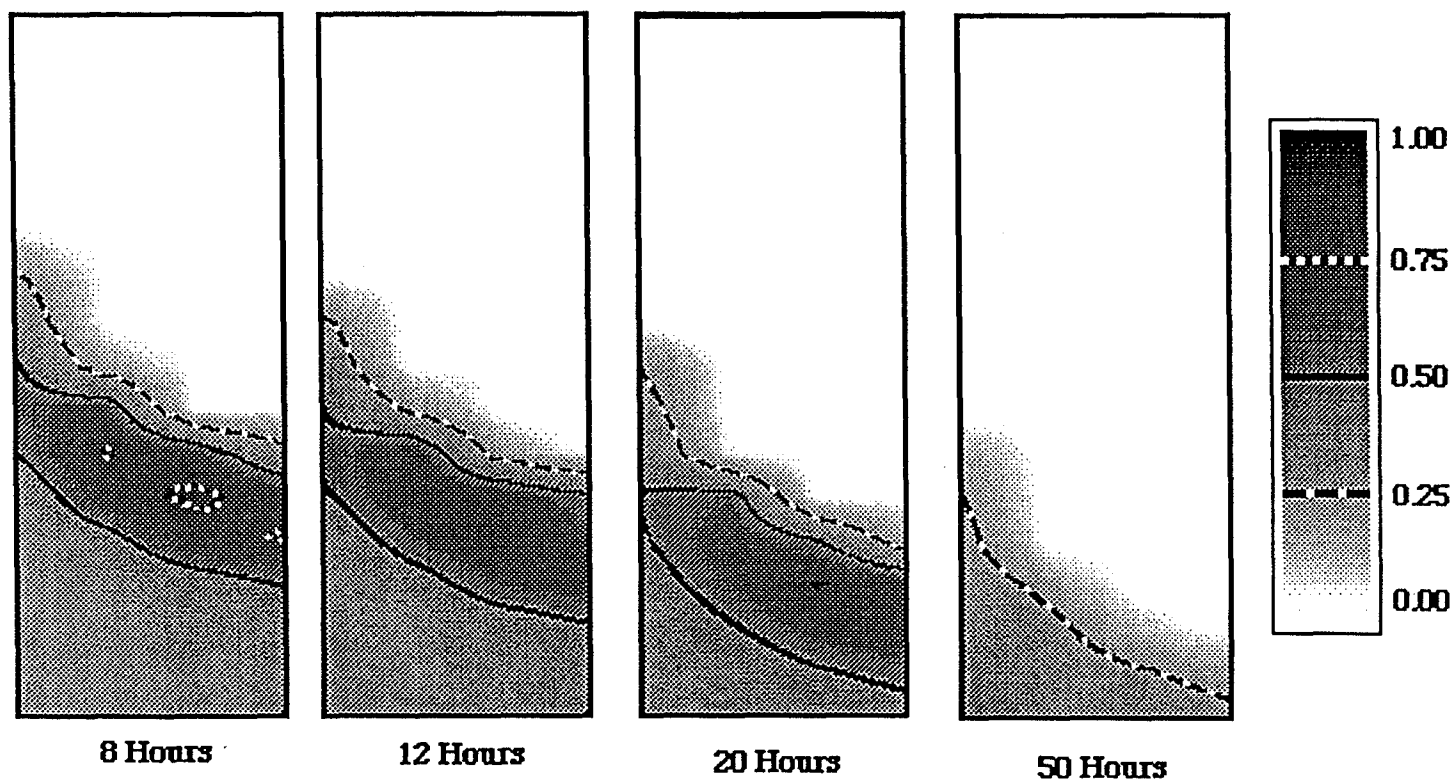
Figure 2 Control volume layout for numerical simulations of contaminant removal from heterogeneous media by cyclic steam injection and vacuum extraction.





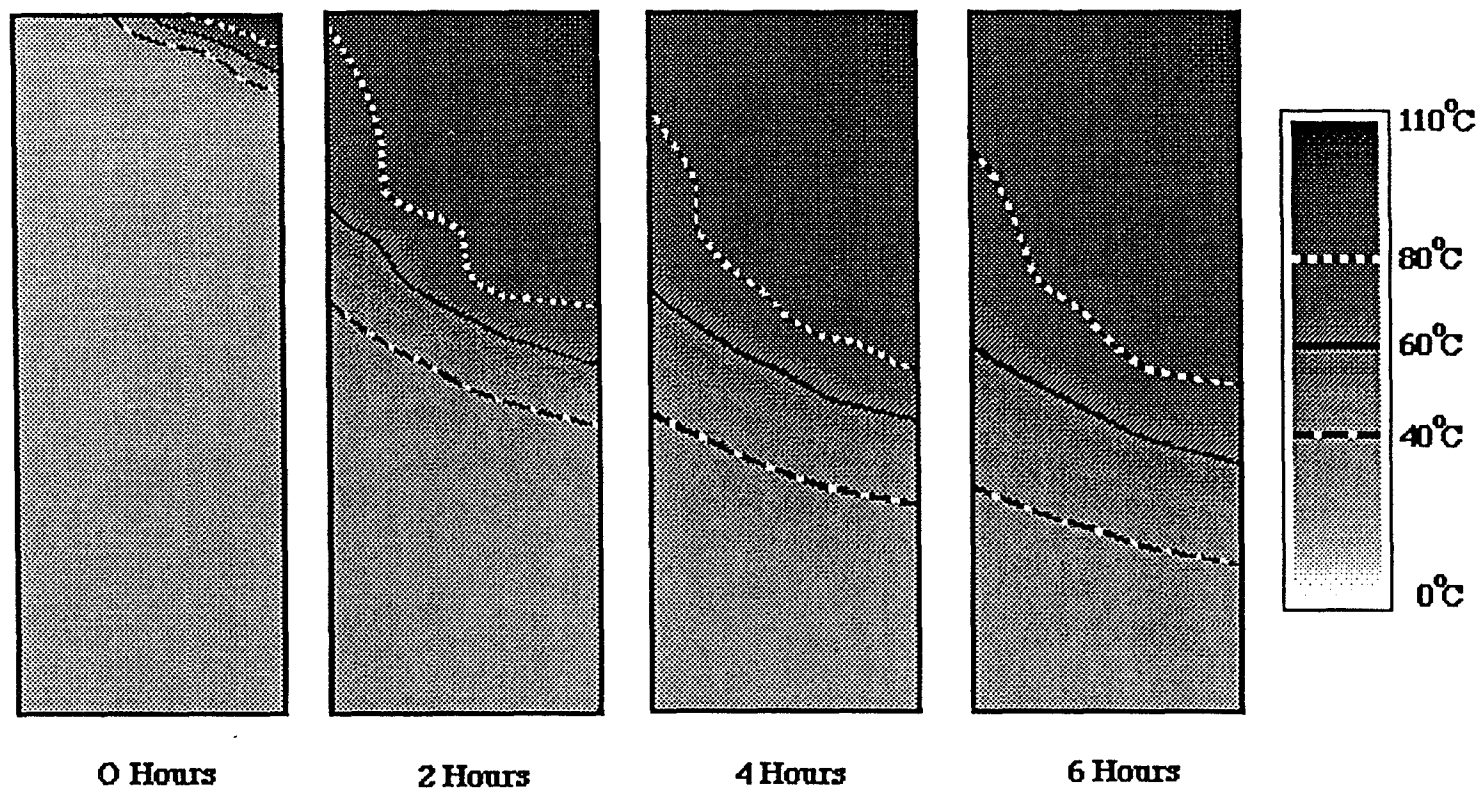
TCE Saturation Profile – 30% Initial TCE Saturation

Figure 3a.



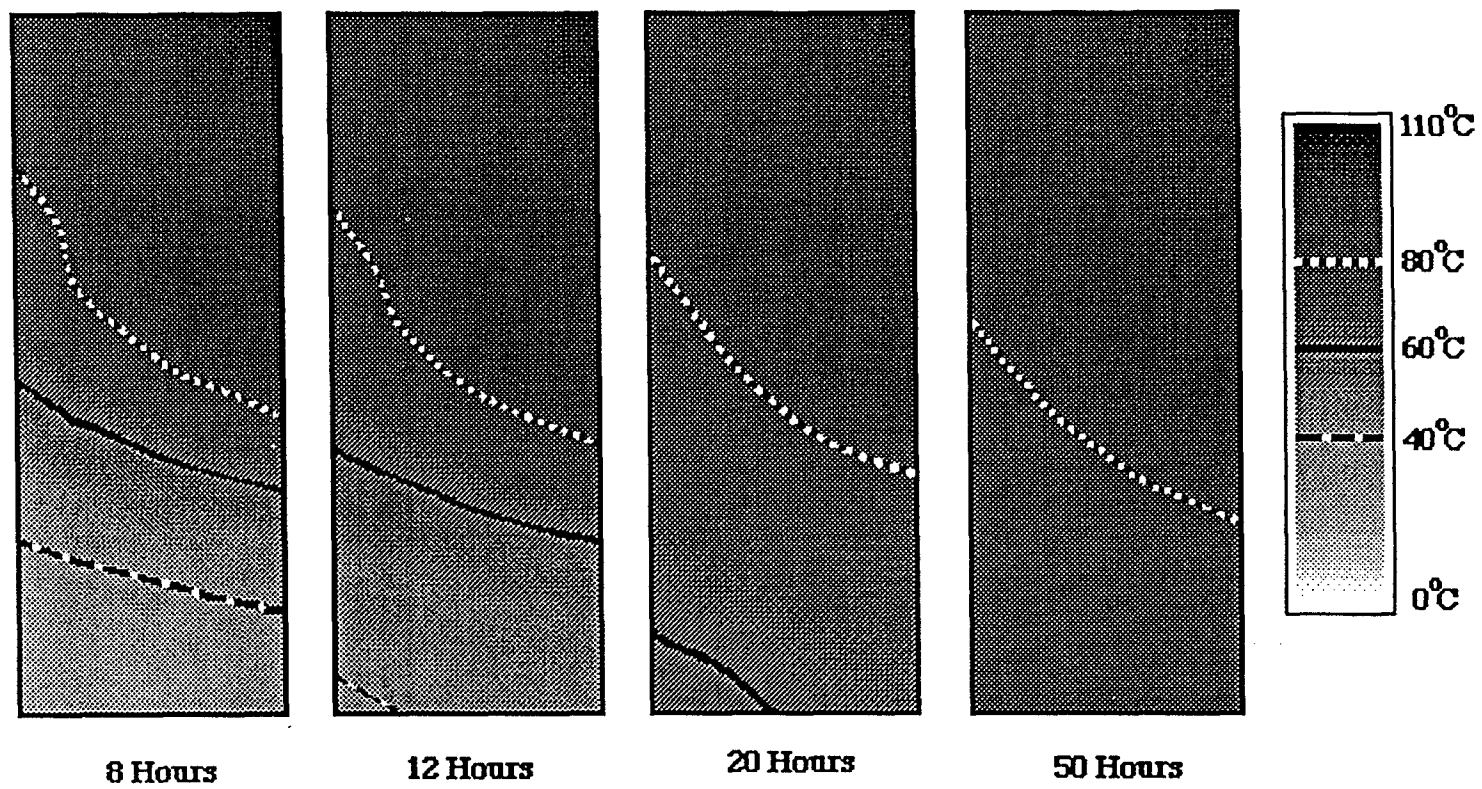
TCE Saturation Profile - 30% Initial TCE Saturation

Figure 3b.



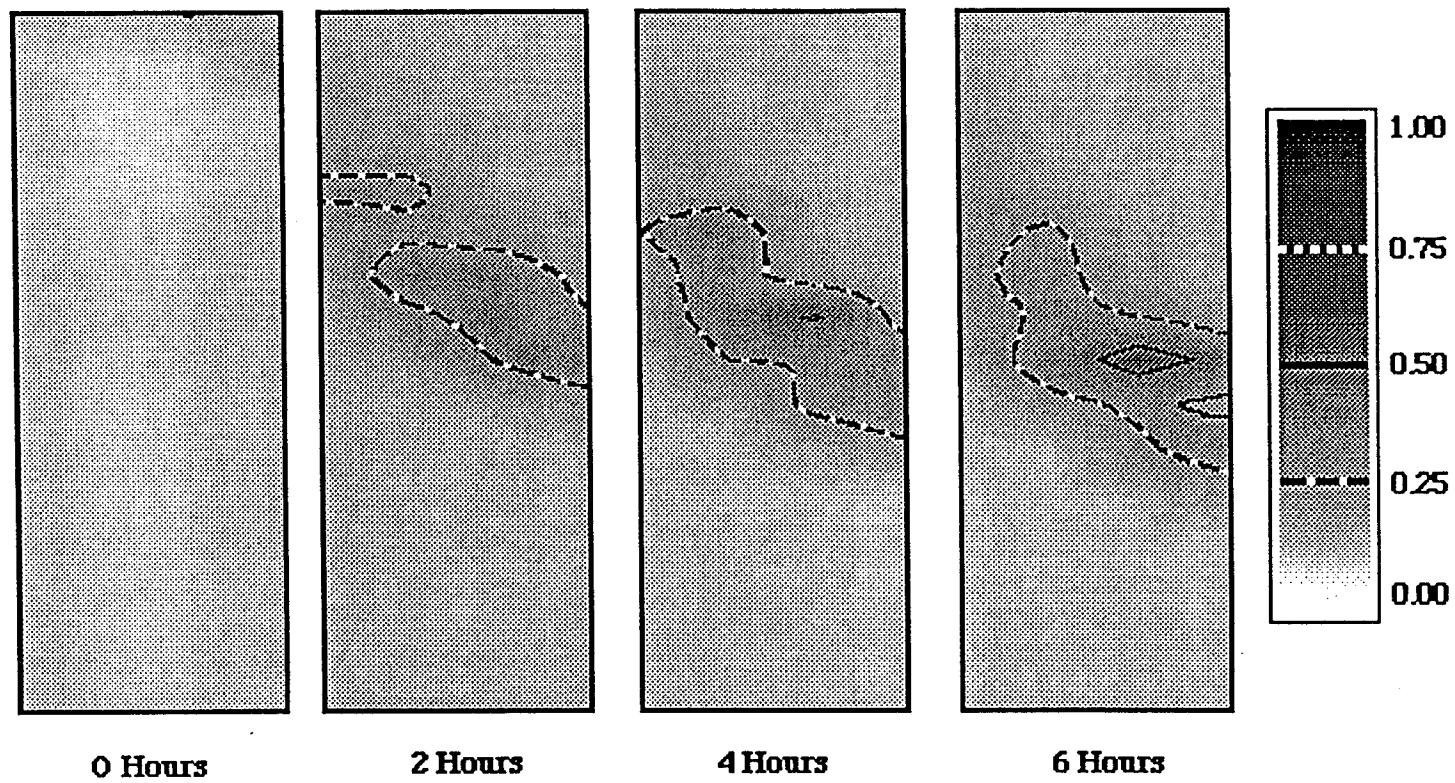
Temperature Profile – 30% Initial TCE Saturation

Figure 4a.



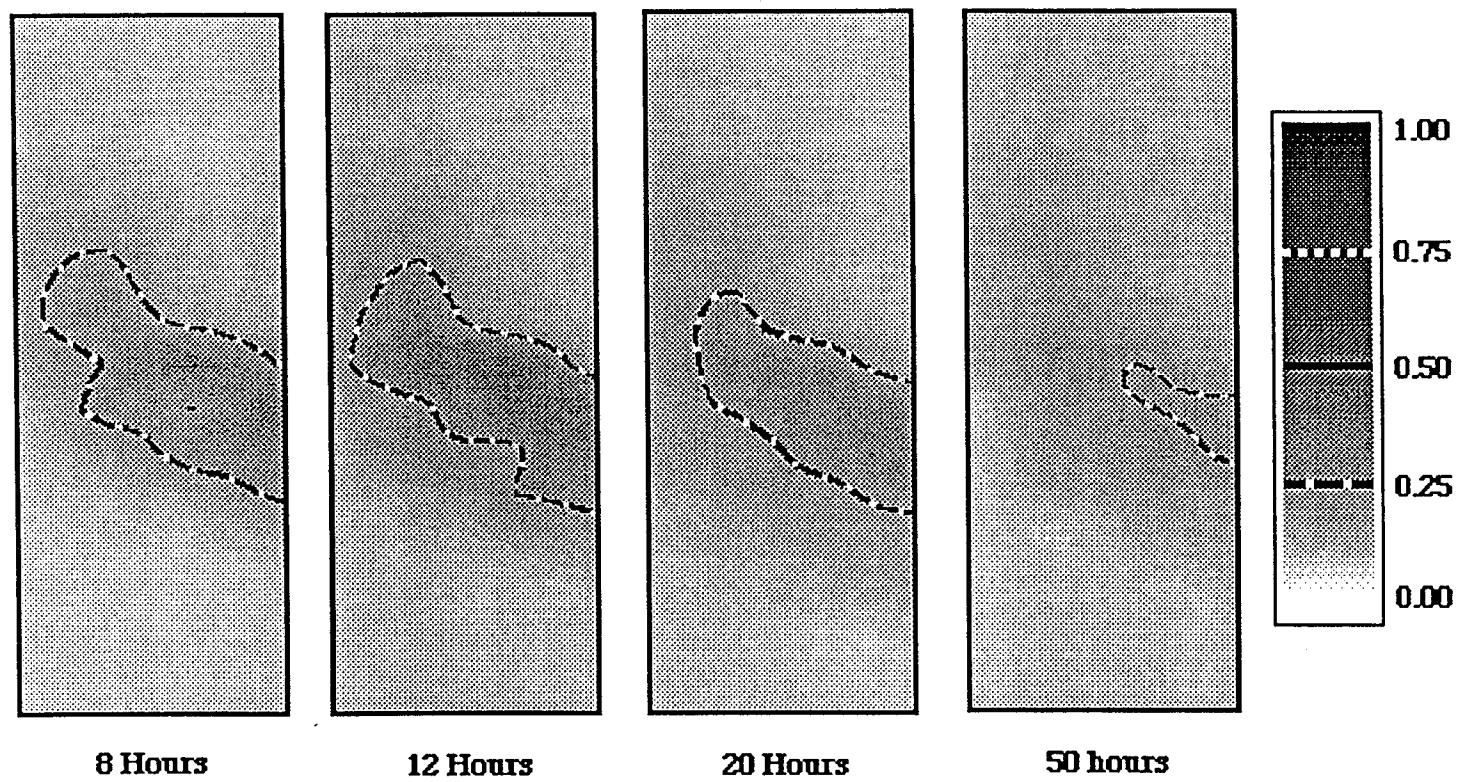
Temperature Profile — 30% Initial TCE Saturation

Figure 4b.



**Water Saturation Profile — 30% Initial TCE Saturation.**

Figure 5a



Water Saturation Profile – 30% Initial TCE Saturation.

Figure 5b.

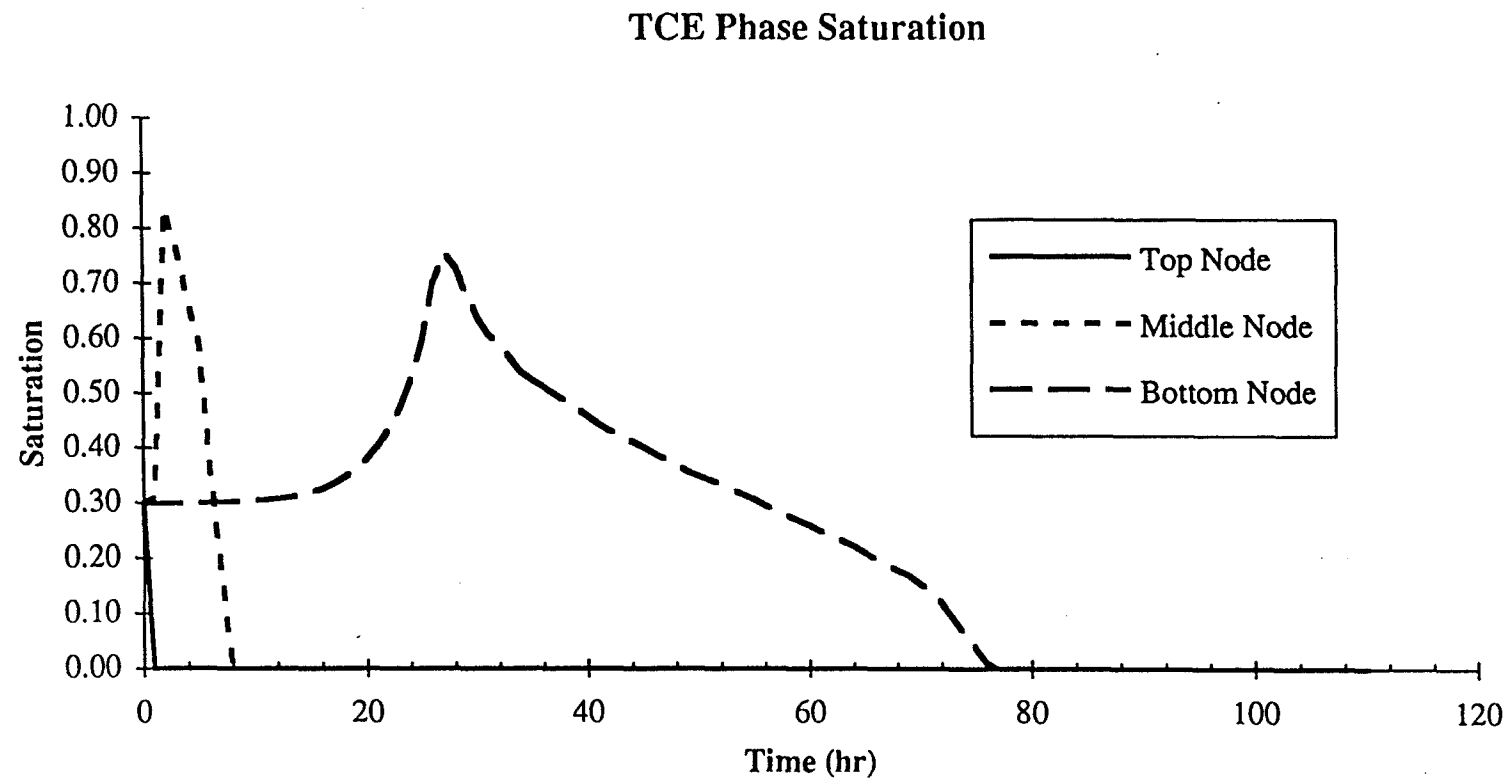


Figure 6. TCE saturation profiles for three nodes during computer simulation.

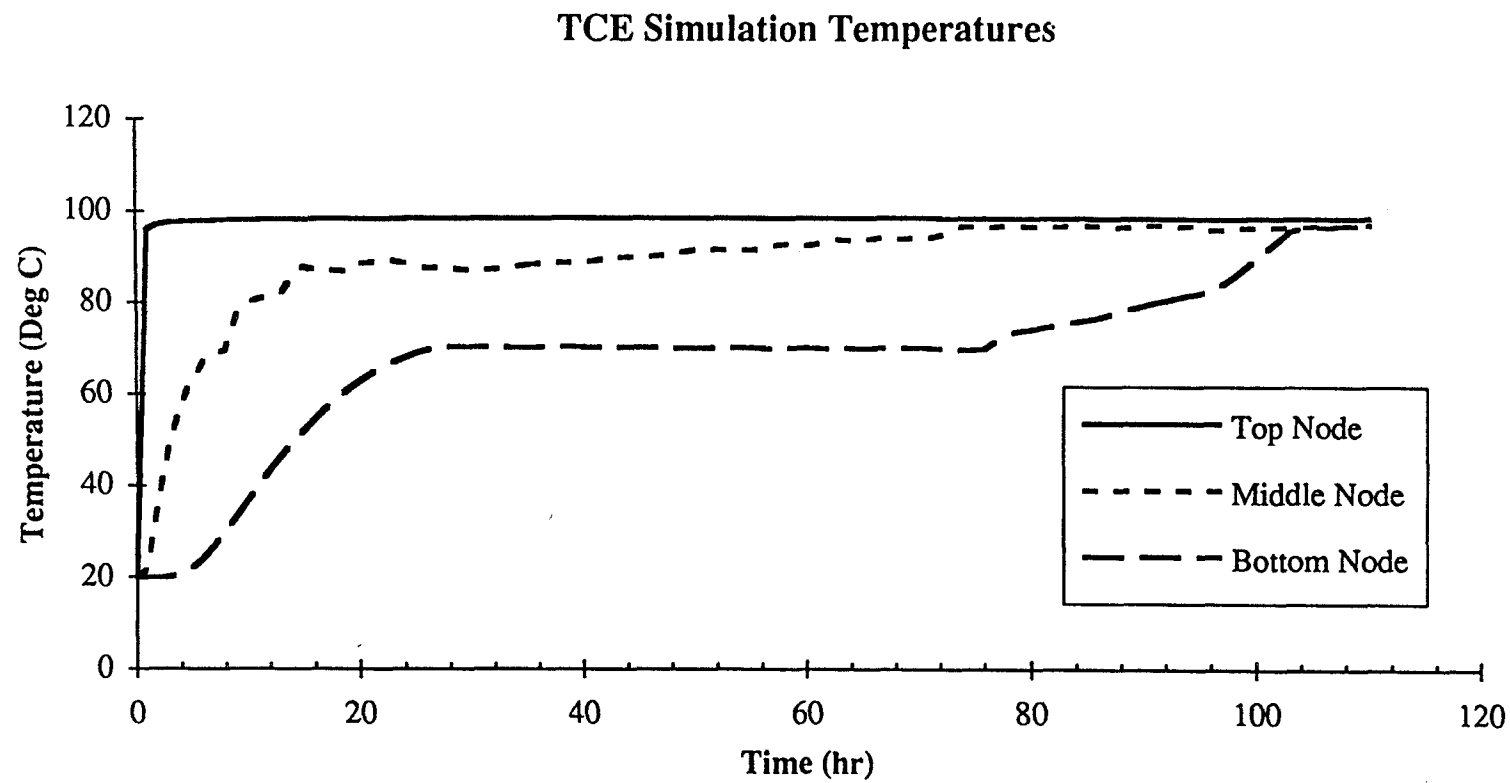


Figure 7. Temperature at three nodes during the computer simulation.



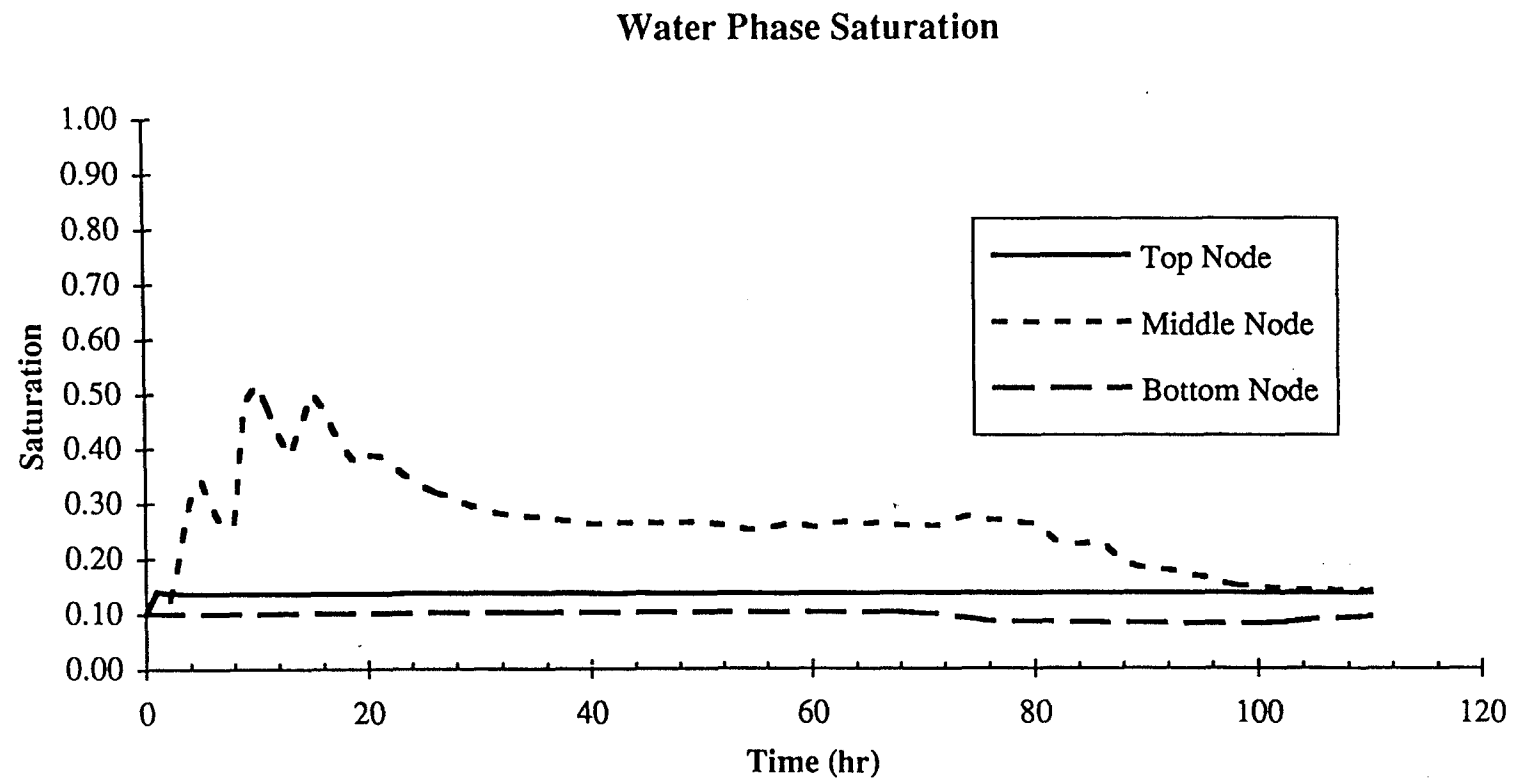


Figure 8. Water phase saturation at three nodes during the computer simulation.

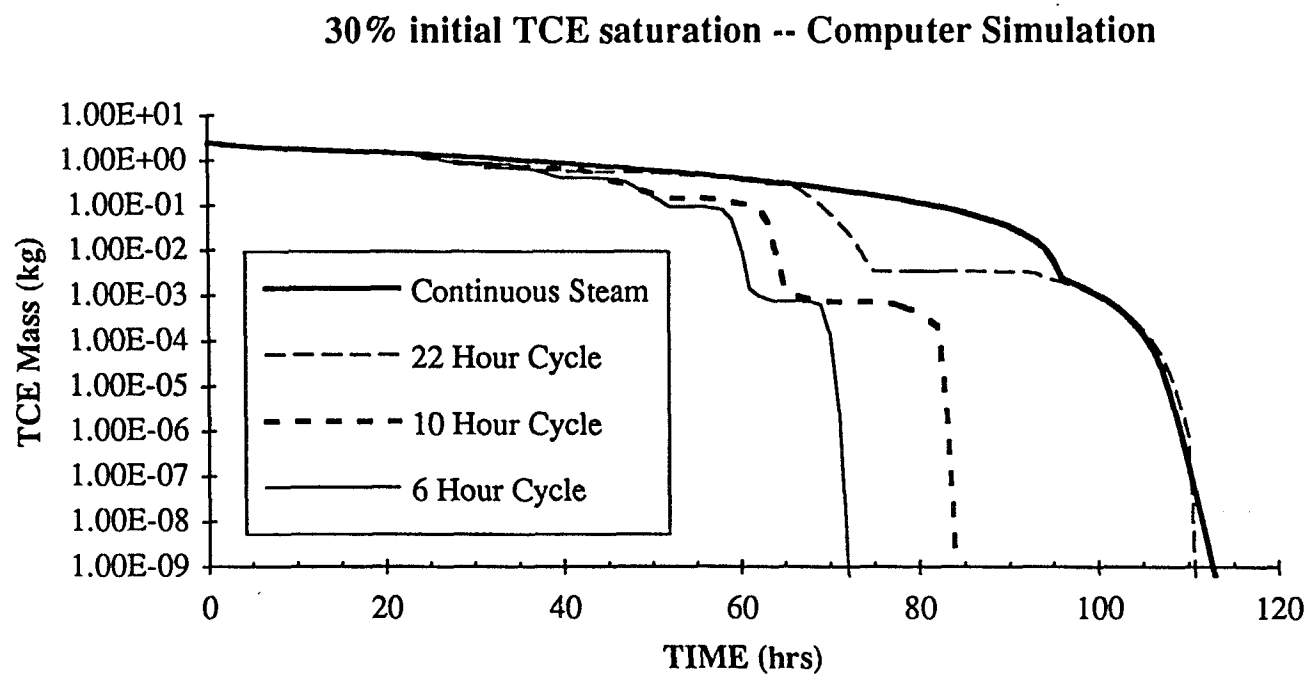


Figure 9. Total TCE mass in system as a function of time for various vacuum/steam cycle times beginning at 22 hours.

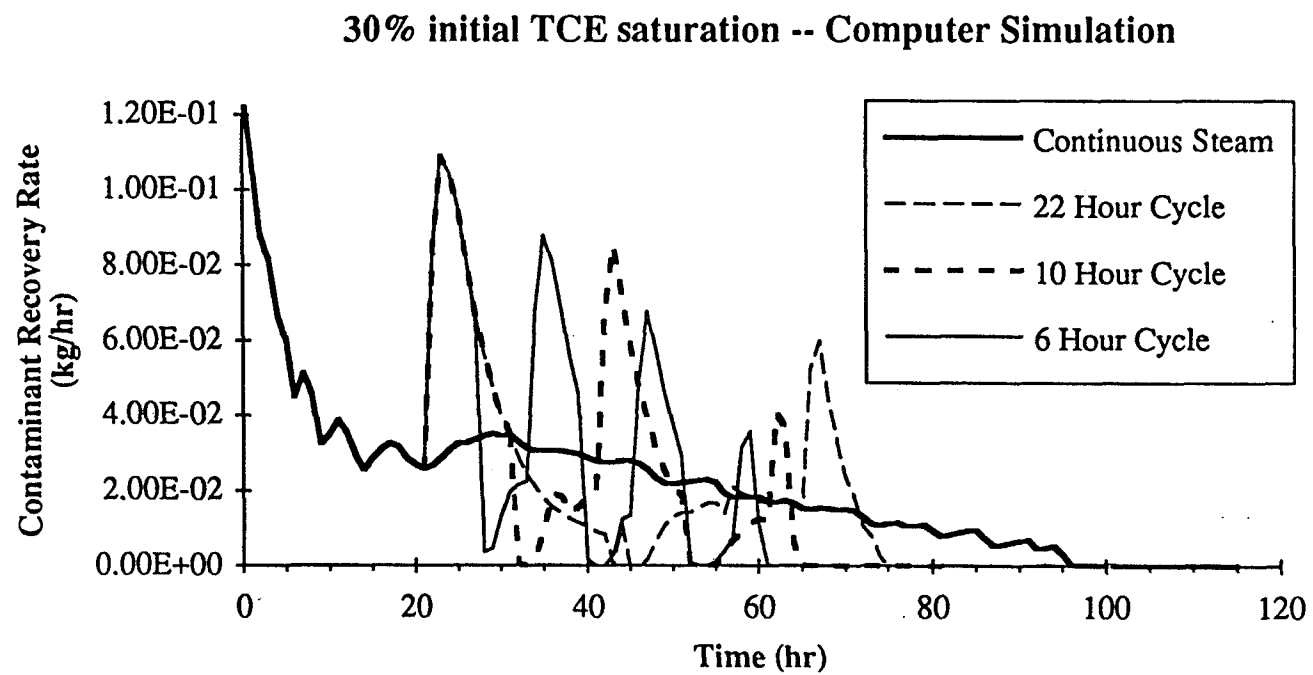
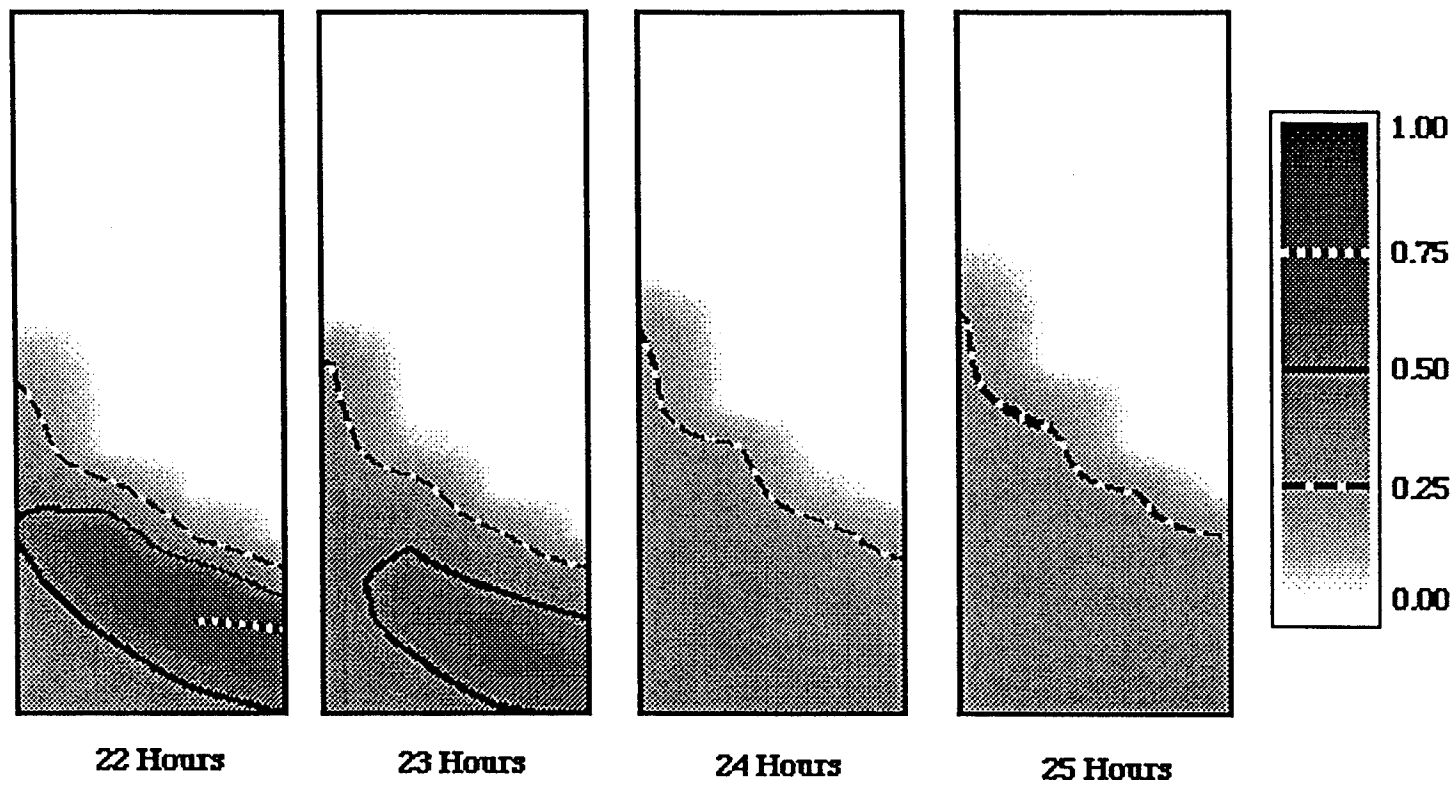
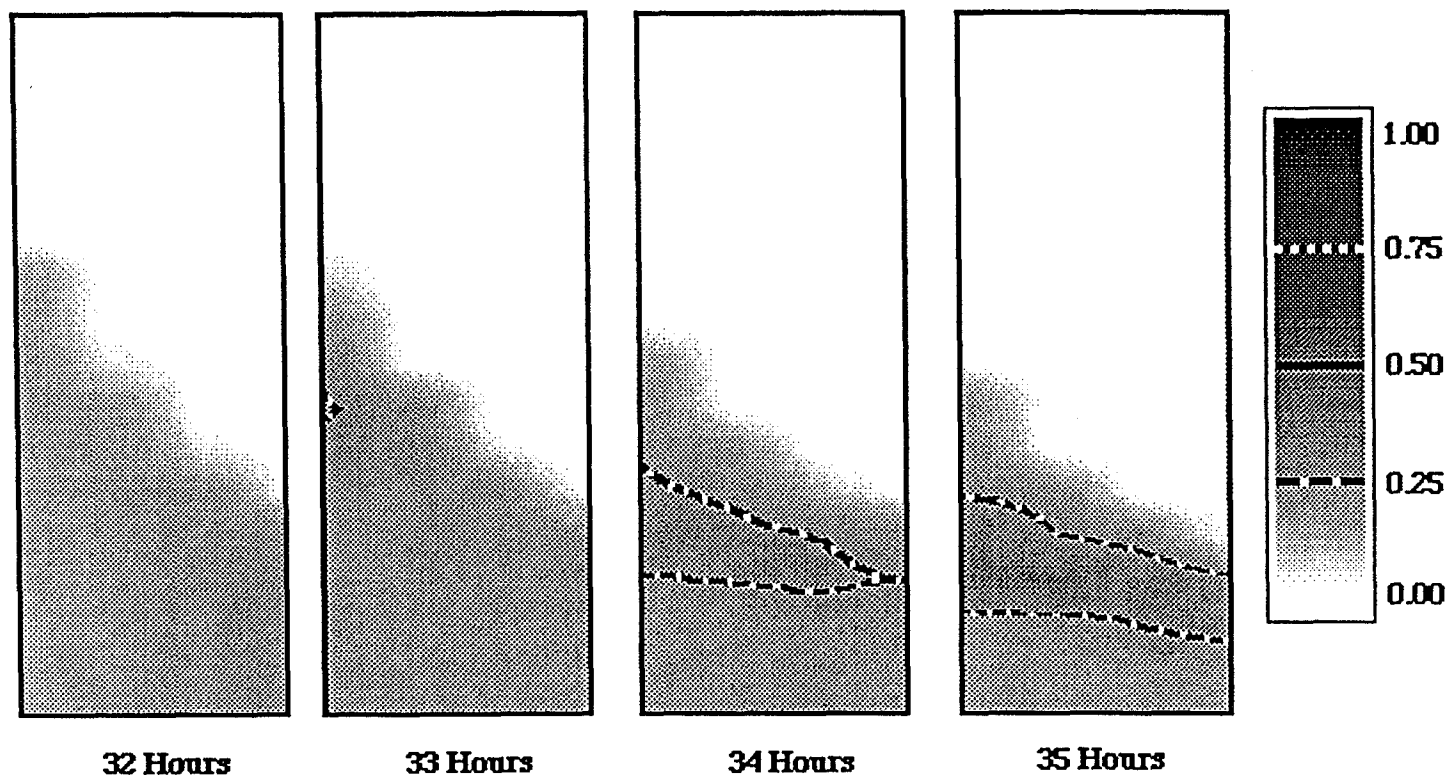


Figure 10. Contaminat removal rate for computer simulation for various steam/vacuum cycle times starting at 22 hours

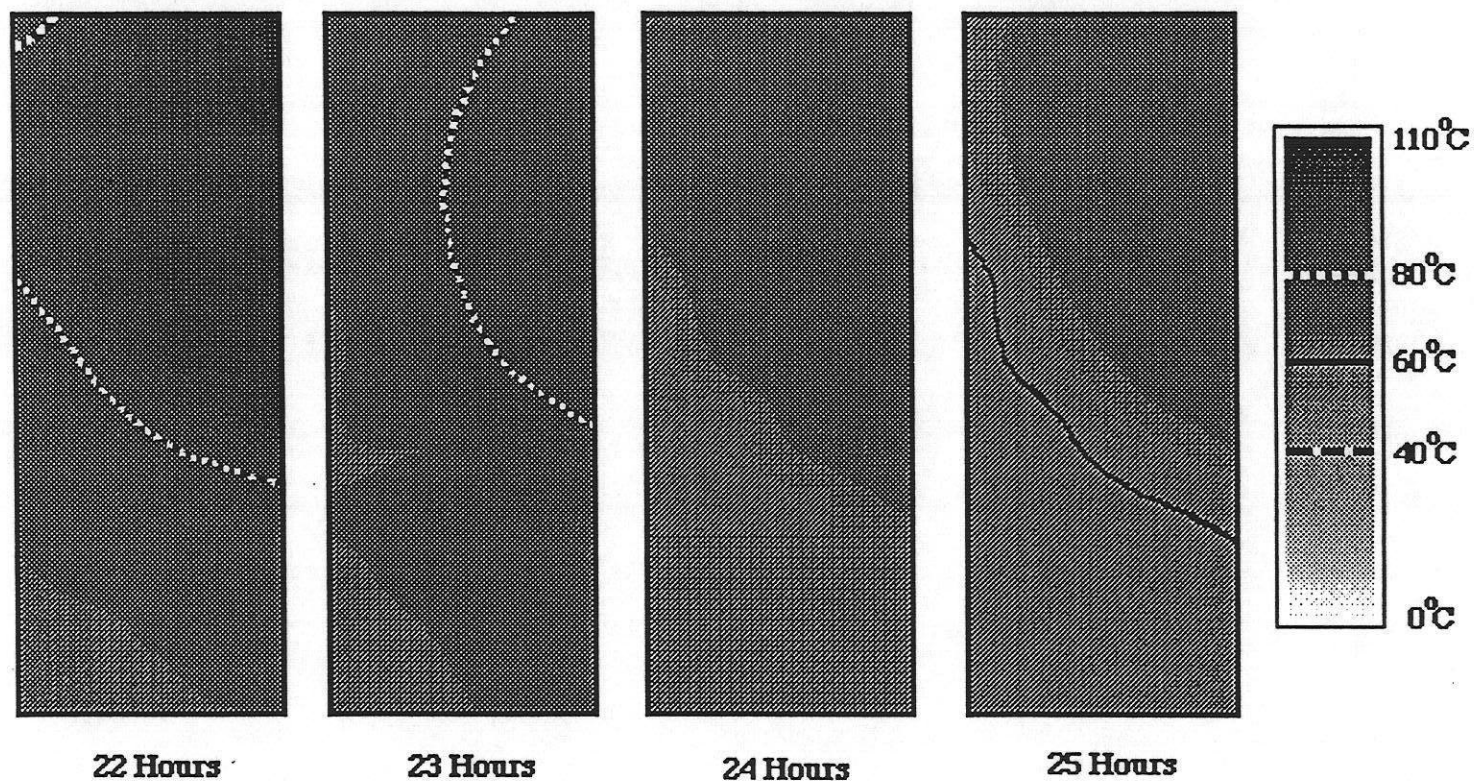


**TCE Saturation Profile – 30% Initial TCE Saturation. First Vacuum Cycle after 22 hours of Continuous Steaming**



**TCE Saturation Profile – 30% Initial TCE Saturation      Steam injection starting  
at 32 Hours after 10 hours of Vacuum**

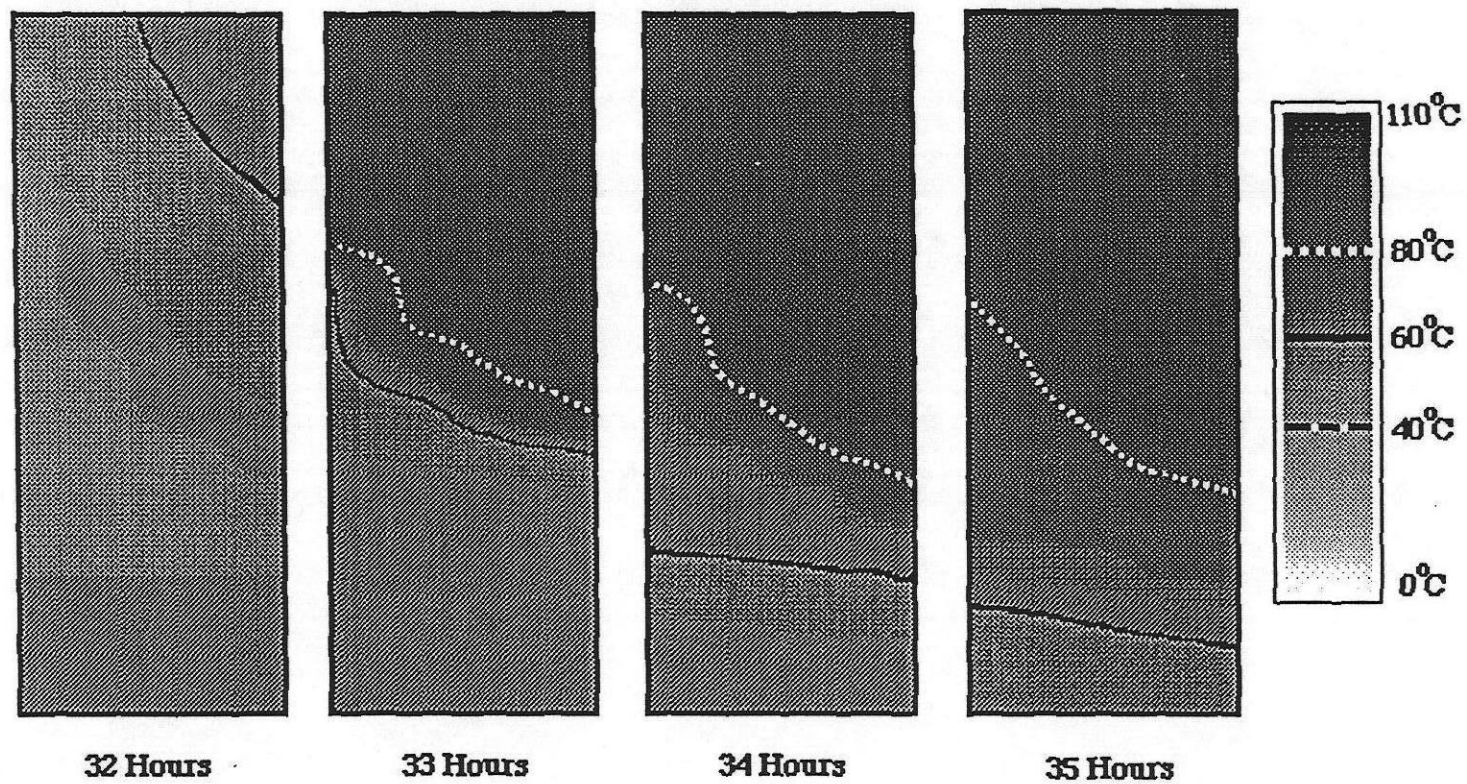
Figure 11b.



Temperature Profile — 30% Initial TCE Saturation.  
22 Hours of Steam Injection

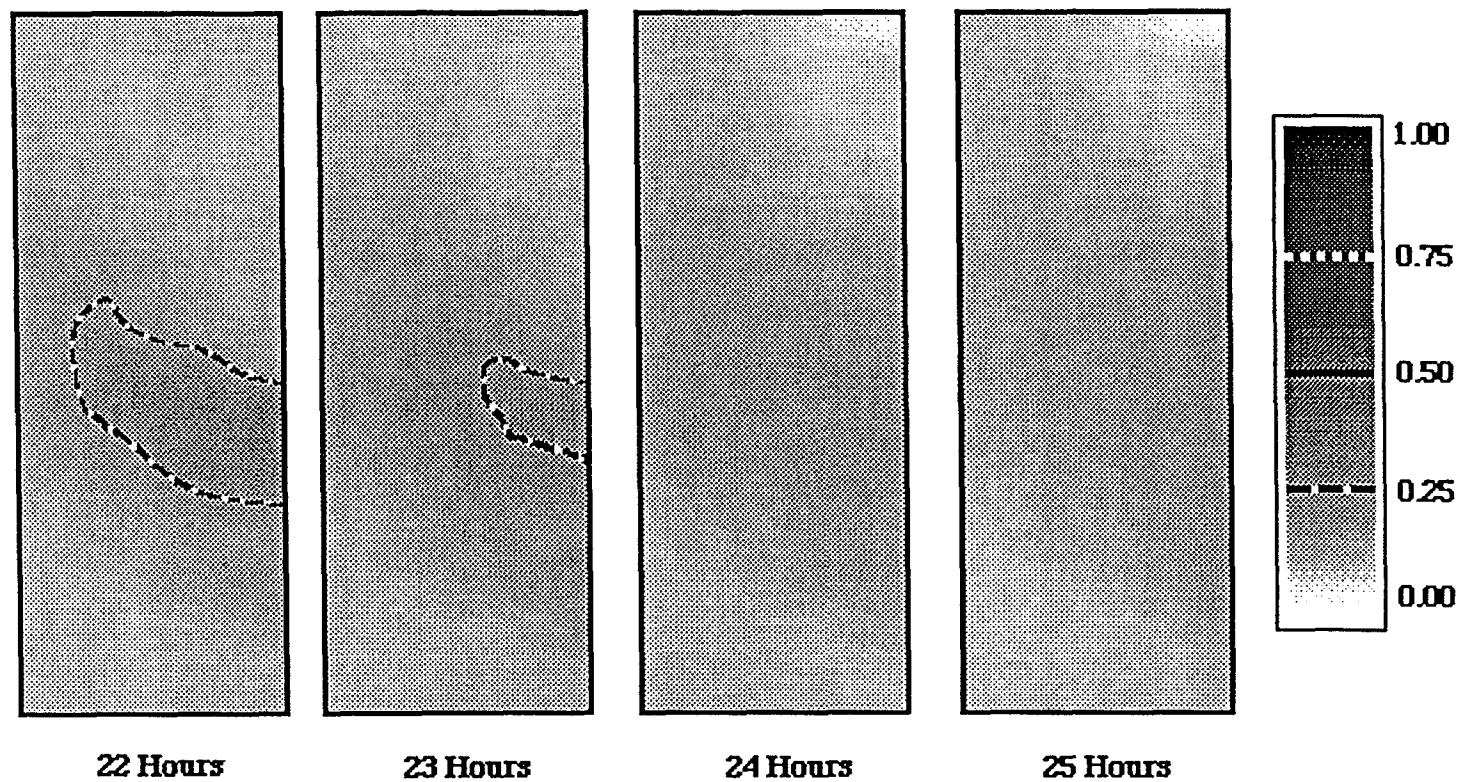
Vacuum after a period of

Figure 12a.



Temperature Profile - 30% Initial TCE Saturation. Steam Injection after 10 Hours of vacuum

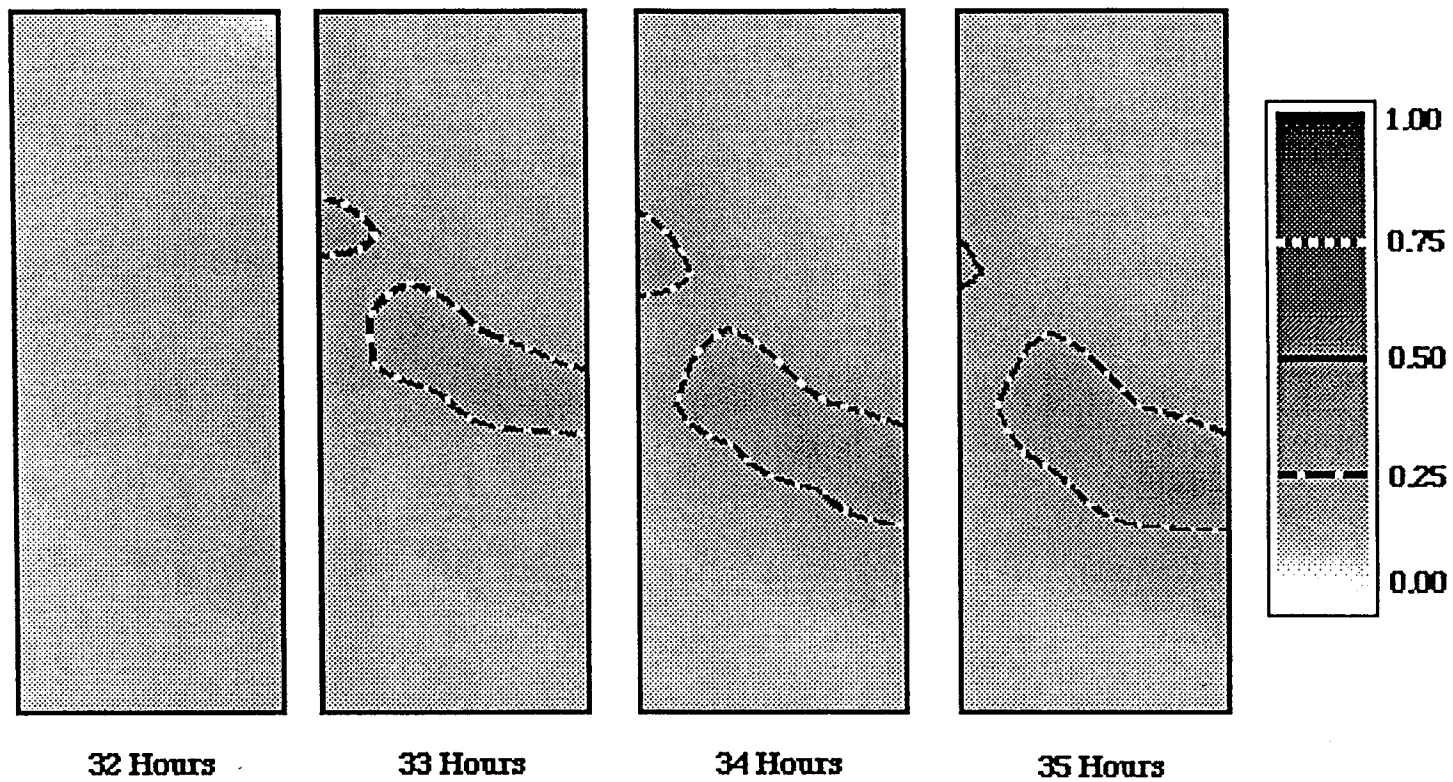
Figure 12b.



Water Saturation Profile – 30% Initial TCE Saturation.      Start of Vacuum after 22  
hours of Continuous Steam

Figure 13a.





**Water Saturation Profile – 30% Initial TCE Saturation. Start of Steam Injection  
after 10 hours of Vacuum**

Figure 13b.

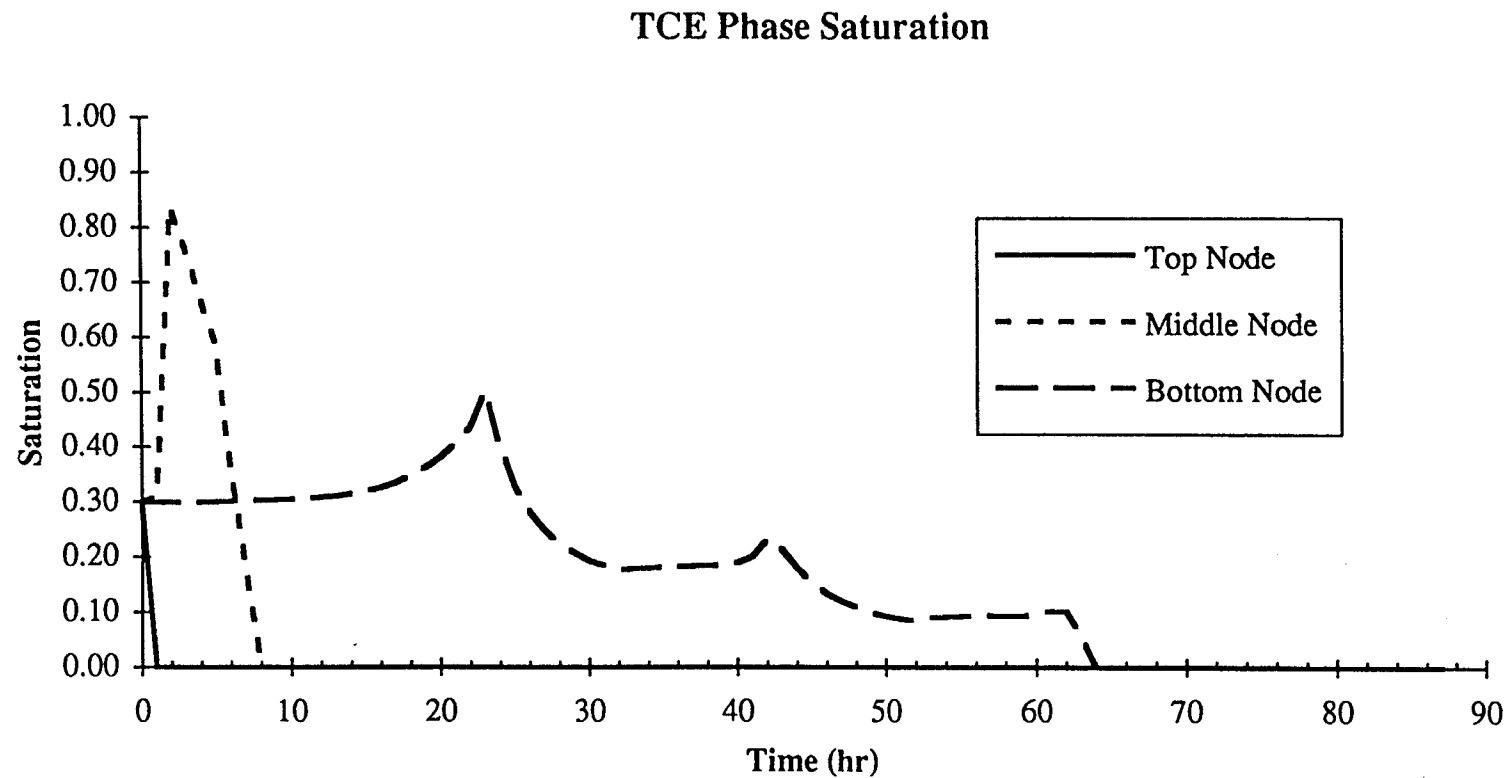


Figure 14. TCE phase saturation for three nodes during computer simulation of a 10 hour cycle time starting at 22 hours.

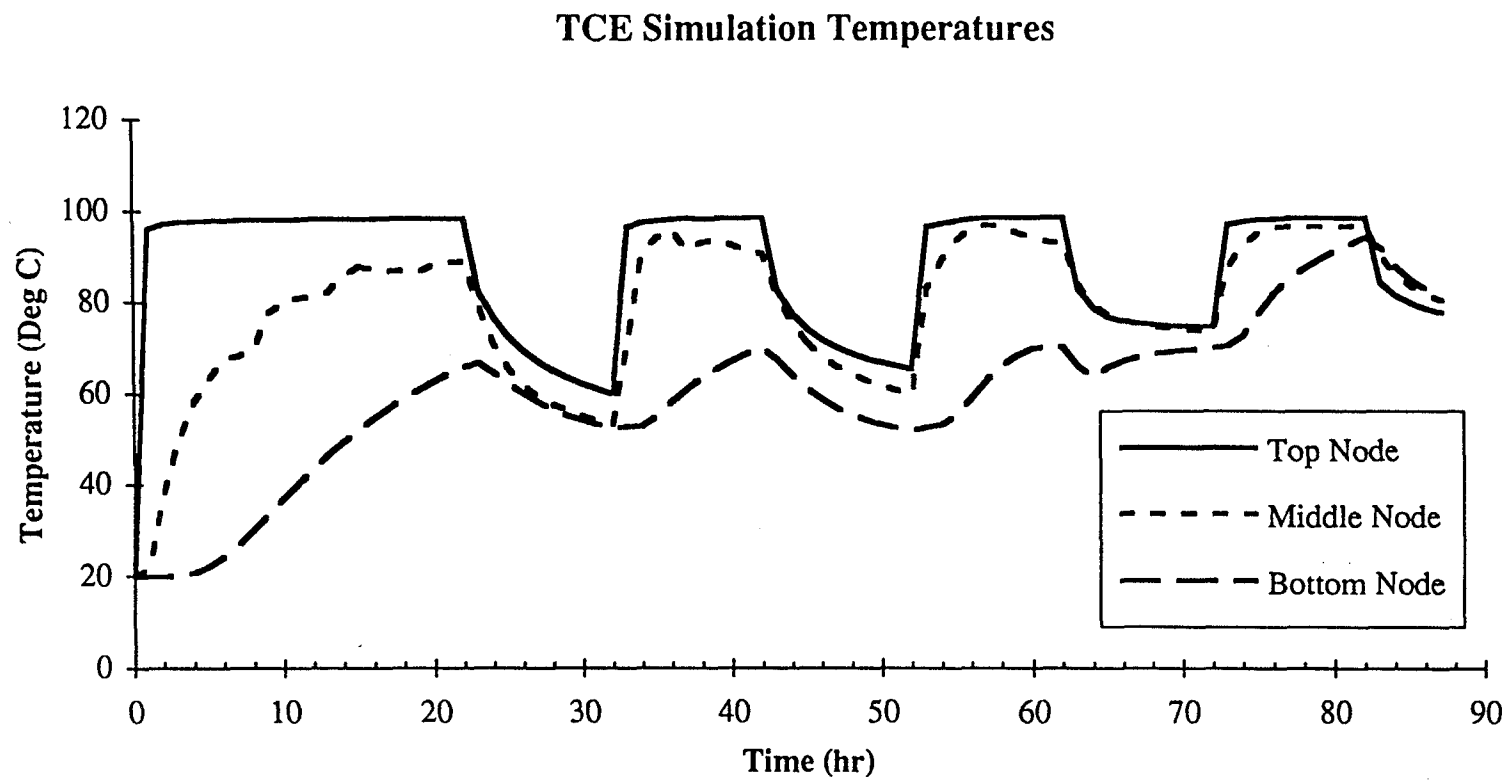


Figure 15. Temperature profiles for three nodes during computer simulation of a 10 hour cycle starting at 22 hours.

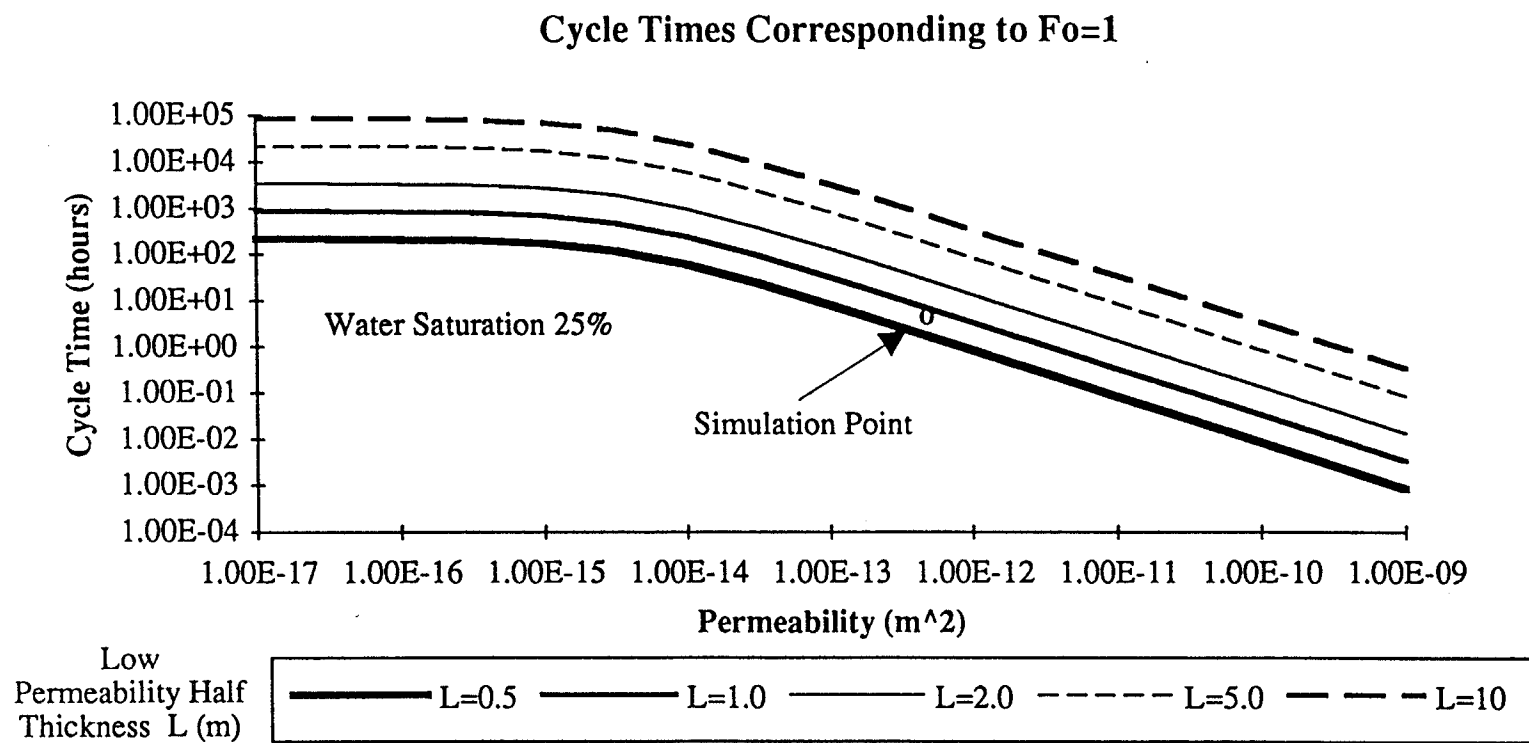


Figure 16. Optimal cycle times for layer of thickness  $2L$  for various bulk permeabilities

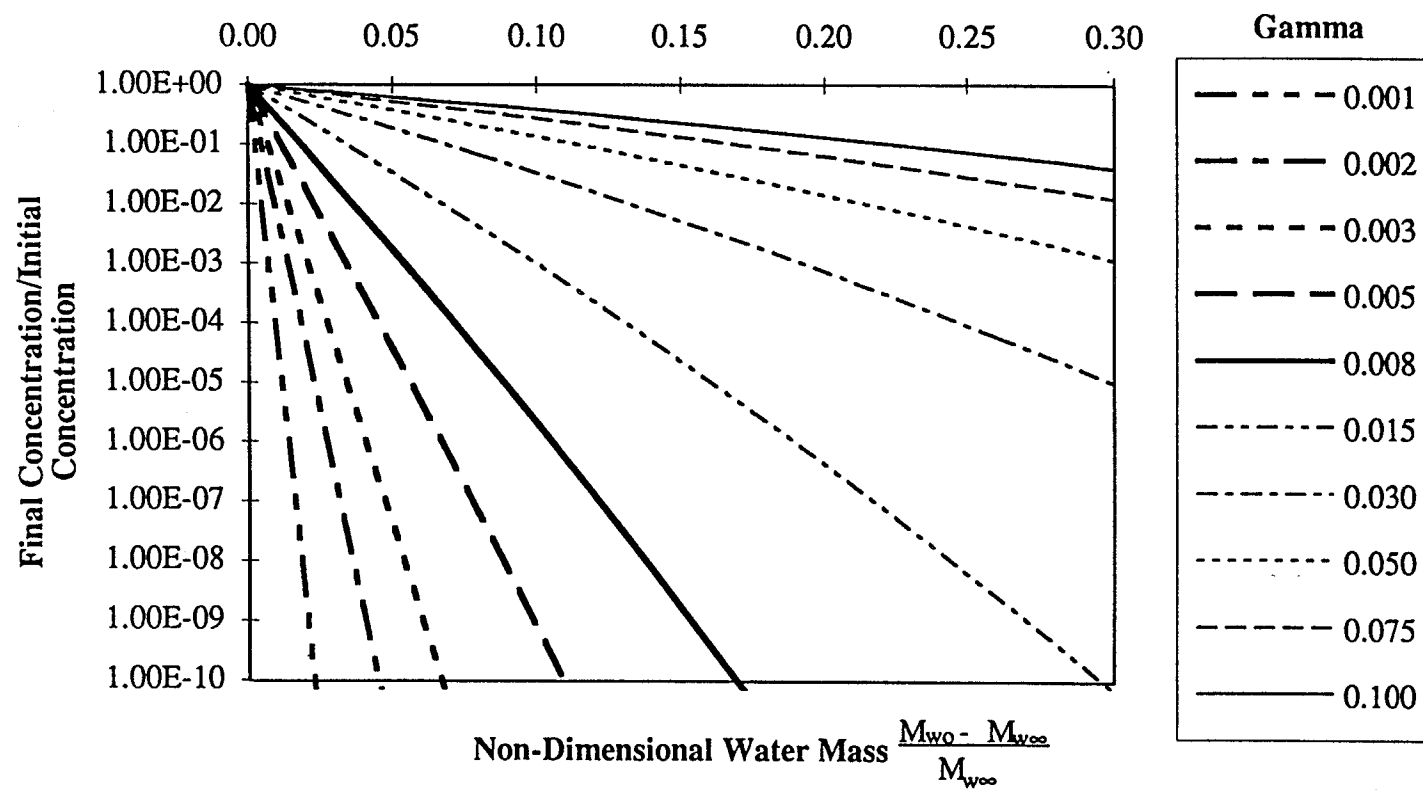


Figure 17. Ratio of final concentration to initial concentration of dissolved NAPL for different values of gamma as a function of non-dimensional water mass

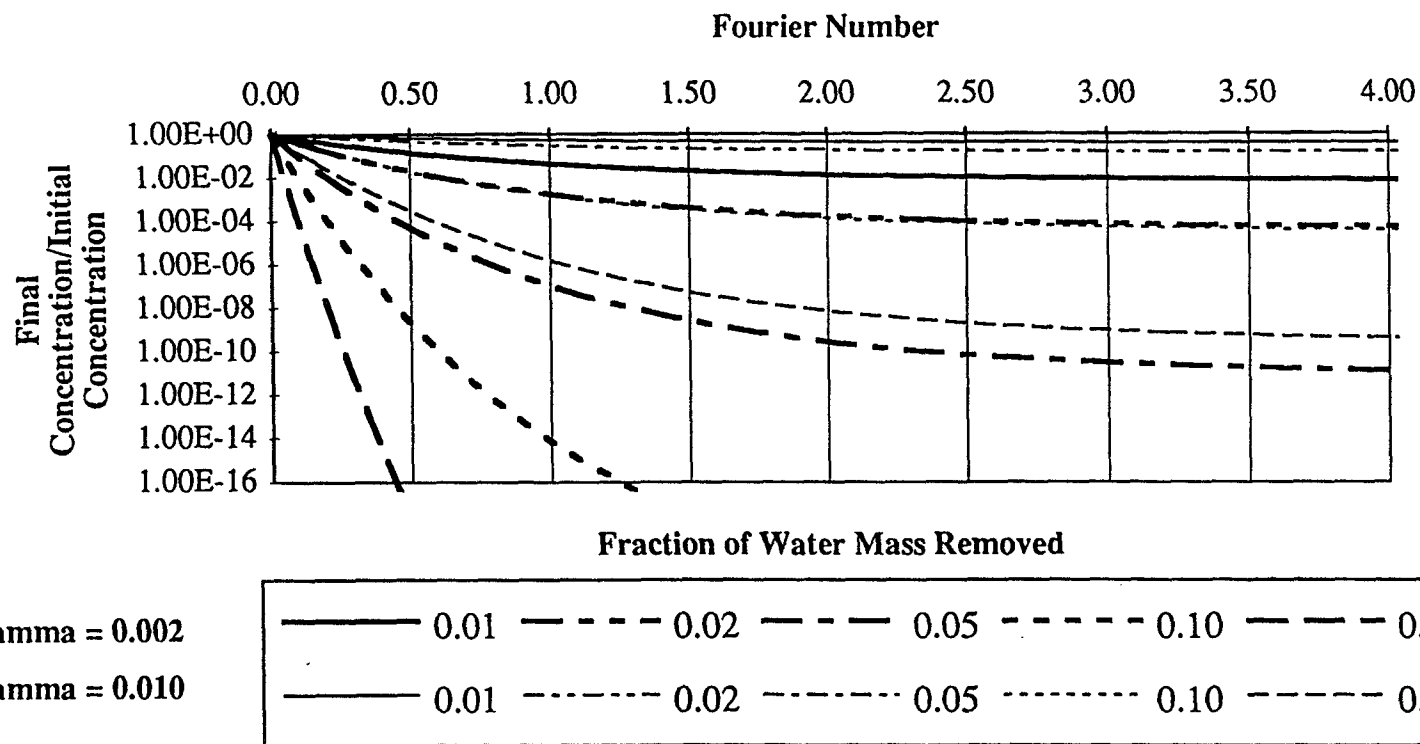


Figure 18. Reduction of the Concentration of Contaminant as a function of Gamma and Mass Fraction of Water Removed

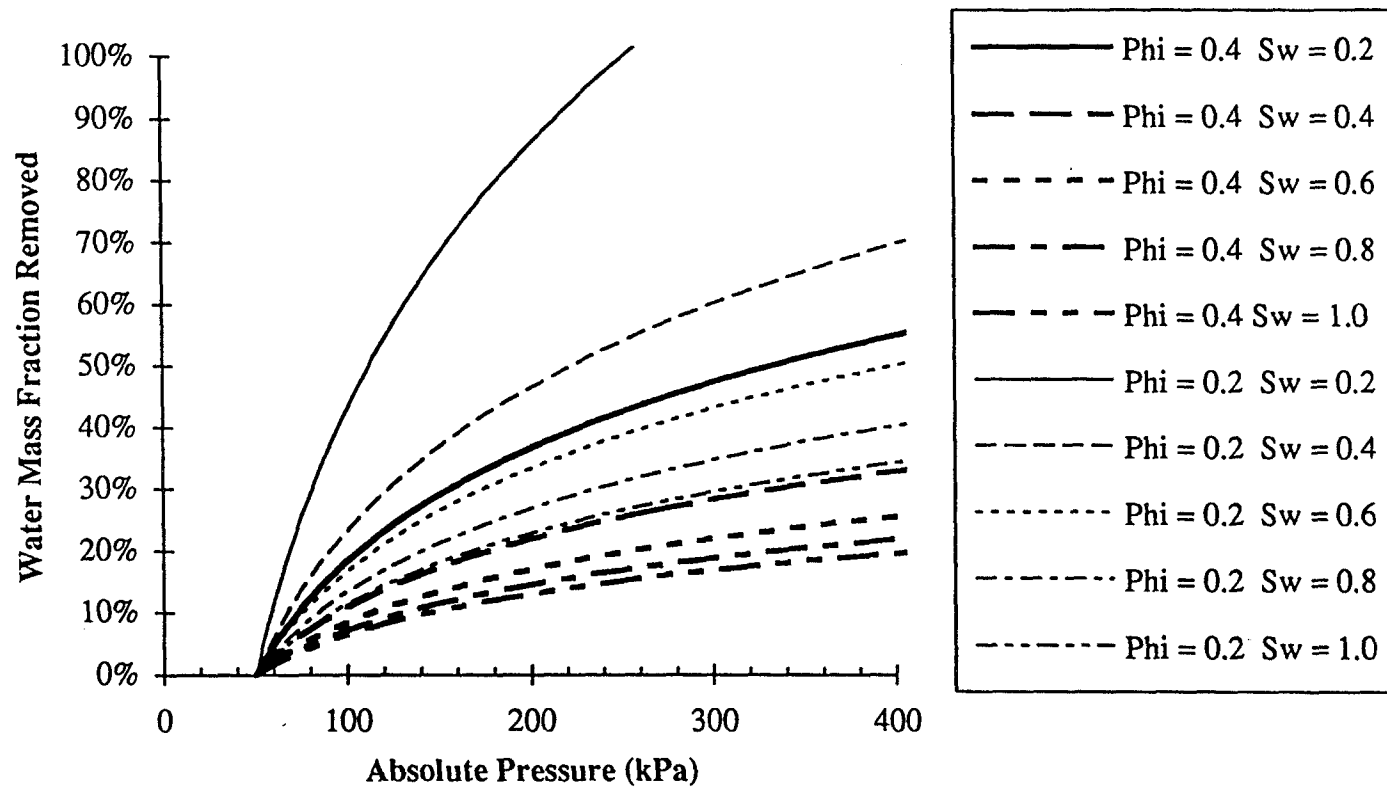


Figure 19. Water mass fraction removed due to an absolute pressure decrease from indicated values to 50 kPa for different porosities and initial water saturations.

PCE-30%			
	Steam Only	44 Hour Cycle	10 Hour Cycle
0.99% clean	162	195	112
1 ppb	184	221	128
Steam time to 1 ppb	184	132	84
Fourier No	-	7.28	1.65

PCE-85%			
	Steam Only	22 Hour Cycle	10 Hour Cycle
0.99% clean	*	*	*
1 ppb	*	*	*
Steam time to 1 ppb	*	*	*
Fourier No	-	3.64	1.65

TCE-30%				
	Steam Only	22 Hour Cycle	10 Hour Cycle	6 Hour Cycle
0.99% clean	90	73	64	61
1 ppb	113	111	84	73
Steam time to 1 ppb	113	66	52	46
Fourier No	0	3.64	1.65	0.99

TCE-85%			
	Steam Only	22 Hour Cycle	10 Hour Cycle
0.99% clean	190	156	124
1 ppb	*	199	144
Steam time to 1 ppb	*	110	82
Fourier No	-	3.64	1.65

\* Simulation not completed

Table 1. Steam cycle efficiencies for various initial conditions.



	Molecular Weight [g/mole]	Vapor Pressure [kPa]	Solubility [ppm]	Mass Fraction Water Phase	Vapor Phase	Gamma [ ]
Benzene	78.11	12.7	1780	0.18%	28%	0.00639
Toluene	92.13	3.80	510	0.05%	11%	0.00463
Ethylbenzene	106.2	1.27	160	0.02%	4%	0.00360
p-Xylene	106.2	1.17	190	0.02%	4%	0.00463
TCE	131.40	10.0	1100	0.11%	33%	0.00332
PCE	165.83	2.5	140	0.01%	13%	0.00112
Carbon Tetrachloride	153.80	15.1	1160	0.12%	48%	0.00241
Chloroethane	64.90	100.7	5710	0.57%	100%	0.00573
Dichloromethane	84.90	58.4	19400	1.94%	80%	0.02427

Table 2. Values for the Mass Fraction Ratio  $\Gamma$  for various chemicals at 20°C

# **STANDARD OPERATING PROCEDURE**

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# TABLE OF CONTENTS AND LOG OF REVISIONS

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## STANDARD OPERATING PROCEDURE

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SOP 3.2	Subsurface Soil Sampling While Drilling	0
SOP 5.1	Water Level Measurements in Monitoring Wells	0
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NOTE: THESE ARE DRAFT SOPS IN THE PROCESS OF BEING FINALLIZED. ALL REFERENCES TO DELIVERY ORDER MANAGER WILL BE CHANGED TO PROJECT MANAGER.

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## CHAIN OF CUSTODY

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### STANDARD OPERATING PROCEDURE

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#### **1.0 PURPOSE**

This Standard Operating Procedure (SOP) establishes the method and responsibilities associated with the maintenance and custody of samples which are to be used to provide data which form a basis for making project related decisions. It outlines the general procedures for maintaining and documenting sample chain of custody from the time of sample collection through sample disposition.

#### **2.0 REFERENCES**

- 2.1 UCB (University of California at Berkeley (UCB) Contractor Quality Control Program Plan
- 2.2 UCB SQP 4.2 Records Management

#### **3.0 DEFINITIONS**

##### **3.1 Chain of Custody**

The Chain of Custody (COC) document is the written record that traces the sample possession from the time each sample is collected until its final disposition, sometimes called the "cradle to grave" record. Chain of Custody is maintained by compliance with one of the following criteria:

- The sample is in the individual's physical possession
- The sample is maintained in the individual's physical view after being in his/her possession
- The sample is transferred to a designated secure area restricted to authorized personnel

- The sample is sealed and maintained under lock and key to prevent tampering, after having been in physical possession.

### **3.2 Waybill**

A document that contains a list of the goods and shipping instructions relative to a shipment.

### **3.3 Common Carrier**

For the purpose of this procedure, the common carrier is any commercial carrier utilized for the transportation of the sample(s) from the field to the laboratory.

## **4.0 PROCEDURE**

### **4.1 Responsibilities**

4.1.1 The Project Manager is responsible for assuring proper COC is initiated at the time the sample(s) are collected and maintained throughout the handling and subsequent transportation of the sample(s) to the designated laboratory. Additionally, he/she is the project authority for determining the disposition and fate of sample(s) which have identified deficiencies (e.g., missed holding times, elevated temperature at receipt, etc.).

4.1.2 The sample team member(s) are responsible for properly documenting and maintaining the COC from the time of sample collection until the sample is delivered to the lab.

4.1.3 Laboratory personnel are responsible for receipt and entry of samples into the laboratory which have been submitted under a COC document. Additionally, samples received will be entered into the laboratory COC procedures by properly documenting and maintaining COC from the moment that they take custody of the sample at the laboratory until the sample is disposed of or returned to the client.

### **4.2 General**

4.2.1 An overriding consideration for data resulting from laboratory analyses is the ability to demonstrate that the samples were obtained from the locations stated and that they reached the laboratory without alteration. Evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal must be documented to accomplish this. Documentation will be accomplished through a COC Record that lists each sample and the individuals performing the sample collection, shipment, and receipt.

4.2.2 The COC document is a preprinted form with a unique six-digit control number in the upper right-hand corner. The white copy will accompany the samples while the yellow field copy will be retained in the project file.

### ***4.3 Field Sample Custody***

4.3.1 Sampling personnel, upon collection of samples for analysis, will properly complete a COC Record form (Attachment 6.1). The COC document will be the controlling document to assure that sample maintenance and custody are maintained thereby assuring the sample(s) are representative of the environment from which they were collected. At a minimum, the following information will be recorded on the COC document:

- The unique identification number assigned to each sample.
- A brief description of the sampling location and a physical description of the sample type.
- The date and time of the sample collection.
- Container type (e.g., glass, poly, brass sleeve, etc.).
- Sample volume and number of containers (e.g., 2 x 40 ml, 3 x 1 liter).
- Sample preservation (e.g., HNO<sub>3</sub>, H<sub>2</sub>SO<sub>4</sub>, 4°C).
- Requested analyses.
- Special instructions to the laboratory including handling requirements, quality assurance/quality control, health and safety, and sample disposition.

- The project name and number.
- The date the analytical report is due.
- The names of all sampling personnel.
- The name and phone number of the project contact.
- The name and phone number of the laboratory contact.
- The name of the courier and the waybill number (if applicable).
- A unique document reference number.

4.3.2 The COC document will be initiated in the field by the person collecting the sample and signed by each individual who has the samples in their possession. Each time that sample custody is transferred, the former custodian must sign over the COC as Relinquished By, and the new custodian must sign on to the COC as Received By. Each signature must be accompanied by the date, time, and the name of their project or company affiliation.

4.3.3 Transferring of COC from sampling personnel to the analytical laboratory will be performed in accordance with the requirements stated below.

4.3.3.1 If the sampling personnel deliver the samples to the laboratory, transfer of COC occurs as follows:

- The sample collector delivers the samples to the laboratory and relinquishes the sample directly to a laboratory representative.
- The collector signs the COC listing his/her name, affiliation, the date, and time. Any person involved in the collection of the sample may act as the sample custodian.
- The laboratory representative must receive the samples by signing his/her name, affiliation, the date, and time on the COC. The laboratory representative may decline to take receipt of the samples if the COC is not properly completed or if the samples are not properly packaged. All designated laboratory personnel may act as the sample custodian.

- One copy of the COC is given to the sample collector to be returned to the project files and one copy is maintained with the samples at the laboratory.

4.3.3.2 If the sampling personnel transfer sample(s) to the laboratory utilizing a common carrier, sampling personnel will retain COC responsibility and the common carrier is not responsible for maintaining sample custody. The sample collectors are responsible for packaging the samples in a manner that meets the COC definition criteria, that is, the samples are sealed to prevent tampering. When transferring samples to the courier for transport, COC procedures are maintained as follows:

- The sample collector lists the courier affiliation and waybill number on the COC.
- The sample collector relinquishes custody by signing his name, affiliation, date, and time. The collector keeps a copy of the relinquished COC for the project file.
- The relinquished original COC is sealed in a watertight plastic bag and taped to the inside of the lid of the container used for transportation.
- The transportation container is sealed to prevent tampering and given to the courier for delivery to the laboratory.
- The sample collector obtains a copy of the waybill from the courier for the project file.
- The laboratory representative must receive the samples by signing his/her name, affiliation, the date, and time on the COC. This copy is maintained with the samples at the laboratory.
- The laboratory representative obtains a copy of the waybill from the courier for the project file.

#### ***4.4 Analytical Laboratory Custody***

4.4.1 Upon receipt at the analytical laboratory, the field generated COC document will be signed, dated, time marked, temperature marked, and laboratory identification will be provided in the appropriate spaces.



4.4.2 Laboratory receipt personnel will enter the samples into the laboratory by implementing the sample custody procedures addressed within their UCB approved QA Program.

4.4.3 After completion of analytical testing, sample remnants not consumed during testing may be kept for six months beyond the completion of analysis, unless otherwise specified by a notation on the COC that samples are to be returned to the project site for disposal. Once this time period has elapsed, the samples will be disposed of and the disposal record number will be recorded on the laboratory record copy of the COC.

## **5.0 RECORDS**

Records generated as a result of implementation of this SOP will be controlled and maintained in the project record files in accordance with SQP 4.2.

## **6.0 ATTACHMENT**

### **6.1 Chain of Custody Record Form**

## CHAIN OF CUSTODY / ANALYSES REQUEST FORM

[illegible]

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## SAMPLE HANDLING, PACKAGING AND SHIPPING

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### STANDARD OPERATING PROCEDURE

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#### **1.0 Purpose**

This Standard Operating Procedure (SOP) outlines the methods and responsibilities for field personnel to use in the packaging and shipping of environmental samples for chemical and physical analysis. This SOP only applies to the packaging and shipping of limited quantity, low concentration environmental samples. This procedure does not apply to those samples considered hazardous materials, hazardous waste, mixed waste, radioactive waste, and/or dangerous goods. Those requirements are specified in the Department of Transportation (DOT) 49 CFR 114-327 and the International Air Transport Association (IATA) procedures. The details within this SOP are only applicable to the general requirements for sample packaging and shipping and should only be used as a guide for developing more job-specific work plans.

#### **2.0 References**

2.1 EPA, September 1987, Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidelines for Conducting Remedial Investigation and Feasibility Studies under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.3 Code of Federal Regulations, DOT 49 CFR parts 100 to 177, Revised October 1, 1992.

2.4 Dangerous Goods Regulations, IATA, January 1, 1994.

2.5 SQP 4.2 Records Management.

### **3.0 Definitions**

#### **3.1 Environmental Sample**

A limited quantity, low concentration sample that does not require DOT or IATA hazardous waste labelling as a hazardous waste or material.

#### **3.2 Hazardous Waste Sample**

Medium or high concentration sample requiring either DOT or IATA labelling as a hazardous waste or material.

#### **3.3 Hazardous Waste**

Any substance listed in 40 CFR Subpart D (260.30 et seq.) or otherwise characterized as ignitable, corrosive, reactive, or toxic as specified in Subpart C (261.20 et seq.) that would be subject to manifest and packaging requirements specified in 40 CFR 262. Hazardous waste is defined and regulated by the U.S. Environmental Protection Agency (USEPA).

#### **3.4 Hazardous Material**

A substance or material in a quantity or form which may pose an unreasonable risk to health, safety, and/or property when transported in commerce. Hazardous material is defined and regulated by DOT (49 CFR 173.2 and 172.101) and IATA (Section 4.2).

#### **3.5 Sample**

Physical evidence collected from a facility or the environment which is representative of conditions at the point and time at which the sample is collected.

### **4.0 Procedure**

#### **4.1 Responsibilities**

4.1.1 Compliance with this procedure is the responsibility of project management, site management, health and safety, and field personnel.

4.1.2 Project Manager - is responsible for the development and review of site-specific work plans which address the specific sample handling, packaging, and shipping requirements for the project. Review the project specific documentation forms to ensure they are appropriate

for the field activities. The Project Manager is also responsible for seeing that field personnel receive proper training and maintain quality assurance/quality control (QA/QC).

4.1.3 Contractor Quality Control (CQC) - is responsible for the periodic review of documentation generated during sample handling, packaging, and shipping and the periodic review and audit of field personnel as they perform the work.

If problems arise, the CQC is also responsible for swift implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to requirements, issuing nonconformances).

#### **4.2 Sample Handling**

4.2.1 Inspect the sampling containers (obtained from the analytical laboratory prior to the sampling event) to ensure that they are appropriate for the samples being collected, correctly preserved, and undamaged.

4.2.2 When collecting a sample always use approved/site specific personal protective equipment (e.g., gloves, etc.) to prevent cross-contamination from sample to sample but also as a health and safety requirement.

#### **4.3 Field Packaging**

4.3.1 Collect the samples in accordance with the site-specific work plans and applicable SOPs.

4.3.2 As soon as possible after sample collection, tightly seal the container, and place a piece of custody tape over or around the cap. The custody tape should be placed over the cap so that any attempt to remove the cap will cause the tape to be broken. Do not place custody tape over a volatile organic analysis (VOA) vial septum.

4.3.3 Place all containers in separate, appropriately sized, airtight, seam sealing polyethylene bags (e.g., Ziploc™). Seal the bag, removing any excess air.

4.3.4 Place the bagged container inside an insulating shipping container, "cooler." This cooler should have frozen blue ice inside to assure samples remain cool, "4°," during transit from field to the packaging location.

4.3.5 Because blue ice does not maintain the 4°C standard required for sample shipping, it should only be used while in the field collecting samples.

4.3.6 Maintain the samples under chain of custody (COC) (Attachment 6.1) in accordance with the site-specific work plans and appropriate SOPs.

#### **4.4 Sample Packaging**

4.4.1 Inspect the integrity of the shipping container. The container is generally a "cooler" constructed of heavy plastic or metal with appropriate insulating properties so that variations in temperature during shipping are minimized. Also make sure that the drain plug has been sealed with nylon reinforced strapping tape or mailing tape.

4.4.2 Place two to four inches of absorbent packaging material (e.g., Vermiculite™) in the bottom of the shipping container.

4.4.3 Carefully check the COC record against the collected sample labels and containers to ensure that the sample numbers, sample description, date and time of collection, container type and volume, preservative, and the required analytical methods are correct and in agreement.

4.4.4 Place the samples in the shipping container, allowing sufficient room between the samples to place ice and/or packing material.

4.4.5 Double bag and seal crushed or cubed ice in heavy-duty polyethylene bags. Place these bags of ice on top of and between samples. Blue ice should not be used for sample shipping; it does not maintain the 4°C temperature necessary for regulatory compliance. Include a VOA vial of tap water clearly labeled "temperature check" so that the laboratory can verify the temperature of the samples upon receipt. The remaining space will be filled with packing material.

4.4.6 All samples requiring temperature preservation stated at 4°C will be acceptable "as in" within the range of 4°C  $\pm$  2°C. The laboratory should record the temperature of receipt upon the COC. For all samples received from 6°C to 10°C, the sample(s) and temperature (in 1°C increments) will be noted on the COC and then analyzed. For samples with temperatures greater than 10°C, the samples will be rejected by the laboratory for analysis and immediately reported to the Project Manager. For VOA samples below 0°C, the samples will be rejected and also reported.

#### **4.5 Sample Shipping**

4.5.1 The person in charge of sample custody will time, date, and sign over relinquishment of custody on the COC. When a common carrier is to be used for sample shipment, also record the air/waybill number (tracking number) and the name of the carrier on the COC record. Place the original copy of the COC record in a sealed, clear plastic envelop or bag and tape the COC record envelope to the inside lid of the shipping container. Retain a copy of the COC record for tracking purposes.

4.5.2 Using nylon reinforced strapping tape or mailing tape, seal the shipping container.

4.5.3 Place custody tape over opposite ends of the lid.

4.5.4 Mark the container "THIS END UP," or apply arrow labels that indicate the proper position to be maintained during shipping.

4.5.5 Apply a label stating the name and address of the shipper and the receiving laboratory on the outside of the cooler.

4.5.6 Turn the sample over to the courier or carrier for delivery to the laboratory. All samples should be shipped by the fastest available method to the laboratory as soon as possible after sample collection.

NOTE: The courier or carrier is not responsible for sample custody and is not required to sign the COC.

4.5.7 Contact the appropriate laboratory personnel to advise them of the sample shipment.

4.5.8 Review the COC and sample collection forms for completeness and turn them over to site or project management.

## ***5.0 Records***

5.1 Records generated as a result of implementation of this SOP will be controlled and maintained in the project record files and in accordance with SQP 4.2.

## ***6.0 Attachments***

6.1 Analysis Request and Chain of Custody Record



## CHAIN OF CUSTODY / ANALYSES REQUEST FORM

[illegible]

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## SUBSURFACE SOIL SAMPLING WHILE DRILLING

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### STANDARD OPERATING PROCEDURE

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#### **1.0 Purpose**

This Standard Operating Procedure (SOP) establishes guidelines and procedures for subsurface soil sampling while drilling. Proper collection procedures are necessary to assure the quality and integrity of all subsurface soil samples. Additional specific procedures and requirements will be provided in the project work plans, as necessary.

#### **2.0 References**

2.1 American Society for Testing Materials (ASTM), 1989, Standard Method for Penetration Test and Split-Barrel Sampling of Soils, Method D-1586-84, Philadelphia, PA.

2.2 American Society for Testing Materials (ASTM), 1986, Standard Practice for Thin-Walled Tube Sampling of Soils, Method D-1587-83, Philadelphia, PA, pp 304-307.

2.3 American Society for Testing Materials (ASTM), 1986, Standard Practice for Ring-Lined Barrel Sampling of Soils, Method D-3550-84, Philadelphia, PA, pp 560-563.

2.4 SOP 1.1 - Chain of Custody

2.5 SOP 2.1 - Sample Handling, Packaging and Shipping

2.6 SOP 6.1 - Sampling Equipment and Well Material Decontamination

2.7 SOP 14.1 - Hollow Stem Auger Drilling

2.8 SOP 14.2 - Mud Rotary Drilling

2.9 SOP 14.3 - Air Rotary Drilling

- 2.10 SOP 14.4 - Dual Tube Percussion Drilling
- 2.11 SOP 15.1 - Lithologic Logging
- 2.12 SOP 17.1 - Sample Labeling
- 2.13 SOP 17.2 - Sample Numbering
- 2.14 SOP 19.1 - On-Site Sample Storage
- 2.15 SOP 20.1 - Sample Collection, Preservation, and Holding Times
- 2.16 SQP 4.2 - Records Management

### **3.0 Definitions**

#### **3.1 Borehole**

Any hole drilled into the subsurface for the purpose of identifying lithology, collecting soil samples, and/or installing monitoring wells.

#### **3.2 Split-Spoon Sampler**

A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. This device can be driven into resistant (semiconsolidated) materials using a drive weight or drilling jars mounted in the drilling rig. A standard split-spoon sampler (used for performing standard penetration tests) is 2 inches in outside diameter and 1-3/8 inches in inside diameter. This standard spoon typically is available in two common lengths, providing either 20-inch or 26-inch internal longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively. Six-inch long sleeves (tubes) of brass, stainless steel, or plastic are commonly placed inside the sampler to collect and retain soil samples. A five-foot long split-spoon sampler is also available. A California modified split-spoon sampler is also commonly used. The design is similar to the standard split-spoon except the outside diameter is 2 1/2 inches and the inside diameter is 2 inches.

#### **3.3 Shelby Tube Sampler**

A thin-walled metal tube used to recover relatively undisturbed samples. These tubes are available in various sizes, ranging from 2 to 5 inches in outside diameter and 18 to 54 inches in length. A stationary piston device is included in the sampler to reduce sampling disturbance and increase sample recovery.

### **3.4 Drilling Jars**

A set pair of linked, heat-treated steel bars. The jars may be attached to a wireline sampling string incorporating a split spoon or other impact sampler. The jars are used to drive the sampler into the soil ahead of the bottom of the borehole.

## **4.0 Procedure**

This section contains both the responsibilities and procedures involved with subsurface soil sampling while drilling. Proper subsurface soil sampling procedures are necessary to insure the quality and integrity of the samples. The details within this SOP should be used in conjunction with project work plans. The project work plans will generally provide the following information:

- Sample collection objectives
- Locations of soil borings and target horizons or depths of soil samples to be collected
- Numbers and volumes of samples to be collected
- Types of chemical analyses to be conducted for the samples
- Specific quality control (QC) procedures and sampling required
- Any additional subsurface soil boring sampling requirements or procedures beyond those covered in this SOP, as necessary.

There are many different methods which may be used for subsurface soil sample collection during drilling. This SOP focuses on the two most common methods of soil sample collection: split-spoon sampling and Shelby tube sampling. At a minimum, the procedures outlined below for these two subsurface soil sampling methods will be followed. If other subsurface soil sampling methods are deemed necessary to meet project objectives, the

procedures for these methods will be updated in this SOP or included in the project work plans.

#### ***4.1 Responsibilities***

4.1.1 The Delivery Order Manager is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

4.1.2 The Contractor Quality Control Manager (CQCM) is responsible for periodic review of field generated documentation associated with this SOP. The CQCM is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

4.1.3 Field personnel assigned to subsurface soil sampling activities during drilling are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Site Superintendent, Delivery Order Manager, or the CQCM.

#### ***4.2 General Sampling Considerations***

The two subsurface soil sampling methods covered in this SOP, split-spoon and Shelby tube, are commonly used in conjunction with hollow stem auger, air rotary and dual tube percussion drilling methods. Split-spoon or Shelby tube sampling may be conducted when drilling with mud rotary methods. However, when using this drilling method the samples are not generally useful for chemical analyses. This is because the samples may become invaded or chemically altered when they are tripped through the drilling mud during sample retrieval. In addition, loose unconsolidated soils may also literally wash out of the samplers when they are tripped through the mud column.

The procedures described in this SOP must be used in conjunction with the SOP proscribed for the specific drilling method used at the site. SOPs 14.1, 14.2, 14.3 and 14.4 specifically cover hollow stem auger, mud rotary, air rotary, and dual tube percussion drilling methods,

respectively. Included in these drilling method SOPs are specific drilling requirements related to subsurface soil sampling. These also include, but are not limited to, site clearance, site preparation, and health and safety requirements. Consequently, the SOP for the specific drilling method to be used at the site, the project work plans, and this SOP must be reviewed together before the initiation of drilling and sampling.

#### ***4.3 Split-Spoon Sampling***

Split-spoon samples for chemical analysis are usually obtained in brass, plastic, or stainless steel sleeves. The types, dimensions and number of sleeves to be used, along with the length and type of sampler, will be stated in the project work plans. The split-spoon sampler, lined with the brass, plastic, or stainless steel sleeves, is connected to the drill rod string or a wireline sampling string and is driven by a drive hammer (140 or 340 pound, depending on the size of the sampler) or drilling jars into the undisturbed soil ahead of the bottom of the borehole. The procedure for collecting samples from the split-spoon sampler will be outlined in the project work plans. The standard procedure is described below.

4.3.1 Calibrate all field analytical and health and safety monitoring equipment according to the instrument manufacturer's specifications. Calibration results will be recorded on the appropriate form(s) as specified by the project-specific work plans. Instruments that cannot be calibrated according to the manufacturer's specifications will be removed from service and tagged.

4.3.2 Wear the appropriate personal protective equipment as specified in the project work plans and the applicable drilling method SOP. Personnel protection will typically include a hard hat, safety glasses, gloves, steel-toed boots, hearing protection, and coveralls.

4.3.3 Between each sampling location and prior to each sampling run, decontaminate the sampler, sleeves, and other sampling equipment as described in SOP 6.1.

4.3.4 Advance the borehole to the desired depth or target horizon where the sampling run is to begin. During drilling, monitor vapors in the breathing zone according to the project work plans, and drilling method SOP.

4.3.5 When the desired sampling depth or target horizon is reached, remove the drill bit or plug from inside the drive casing or augers.

4.3.6 Insert the sleeves into the split-spoon sampler, connect the halves, and screw together the rear threaded collar and front drive shoe. Attach the split-spoon sampler to the bottom end of the drill rod string or wireline sampling string. Set up and attach the specified weight hammer, if used.

4.3.7 Drive the sampler into the soil at the bottom of the borehole. Record the type of sampler assembly and hammer weight on the Visual Classification of Soils form (Attachment 6.1) and/or other appropriate form(s), as specified in the project work plans. To minimize off-gassing of the volatiles, the sampler should not be driven until the sampling team is ready to process the sample.

4.3.8 When conducting penetration testing, observe and record on the Visual Classification of Soils form the number of hammer blows as described in SOP 15.1.

4.3.9 Pull the drill rod or wireline sampling string up from the bottom of the borehole and remove the sampler.

4.3.10 Remove the drive shoe and rear collar from the sampler and open the split barrel.

4.3.11 Remove the sleeves one at a time, starting with the sleeve adjoining the drive shoe. Observe and record the amount of sample recovery on the Visual Classification of Soils form per SOP 15.1. Any observed field problems associated with the sampling attempt (e.g., refusal) or lack of recovery should be noted on the Visual Classification of Soils form.

4.3.12 Select sleeve(s) to be submitted for laboratory analysis. Sample sleeve selection should be based on four factors: judgement that the sample represents relatively undisturbed intact material, not slough; proximity to the drive shoe; minimal exposure to air; lithology; and obvious evidence of contamination. The project work plans will specify which sample sleeves will be submitted for specific analyses and confirm the selection criteria.

4.3.13 Place teflon film over each end of sleeves to be submitted for chemical analysis and seal each end with plastic end caps. Place custody tape over each end cap so that any attempt to remove the cap will break the tape.

4.3.14 Appropriately label and number each sleeve to be submitted for analysis per SOPs 17.1 and 17.2, respectively. The label will be filled out using waterproof ink and will contain, at a minimum, the following information:

- Project number
- Boring number
- Sample number
- Bottom depth of sleeve
- Date and time of sample collection
- Parameters for analysis
- Sampler's initials.

4.3.15 Document the sampling event on the Sample Collection Log (Attachment 6.2) or an equivalent form as specified in the project work plans. At a minimum, this log will contain:

- Project name and number
- Date and time of the sampling event
- Drilling and sampling methods
- Sample number
- Sample location
- Boring number
- Sample depth
- Sample description
- Weather conditions
- Unusual events
- Signature or initials of the sampler.

4.3.16 Appropriately preserve, package, handle, and ship the sample in accordance with the procedures outlined in SOPs 20.1 and 2.1 and the project work plans. The samples shall also be maintained under custody per SOP 1.1. Samples stored on-site will be subject to the provisions of SOP 19.1.



4.3.17 One of the sample sleeves may also be utilized for lithologic logging per SOP 15.1. This sleeve may not then be retained for chemical analysis as soil must be removed from the sleeve to effectively describe the soils/lithology and compile the lithologic log.

4.3.18 Where required by the project work plans, remove the soil from one of the remaining sleeves and place in a seam-sealing, polyethylene bag for organic vapor screening. Place the bag in the sunlight (warm) for at least five minutes, then using an organic vapor probe (e.g., portable photoionization detector, flame ionization detector, or other appropriate instrument), monitor the soil for organic vapors. Record the reading on the Visual Classification of Soils form (Attachment 6.1), the Sample Collection Log (Attachment 6.2), and any other form(s) specified in the project work plans.

4.3.19 Repeat this sampling procedure at the intervals specified in the project work plans until the bottom of the borehole is reached and/or last sample collected.

#### ***4.4 Thin Walled or Shelby Tube Sampling***

A thin-walled tube, or Shelby tube sampler may be used to collect relatively undisturbed soil samples. The procedure for collecting soil samples using a Shelby tube sampler should be outlined in the project work plans. The standard procedure is described below.

4.4.1 Calibrate all field analytical and health and safety monitoring equipment as discussed in Section 4.3.1.

4.4.2 Wear the appropriate personal protective equipment as described in Section 4.3.2.

4.4.3 Between each sampling location and prior to each sampling run, decontaminate the sampler and other sampling equipment as described in SOP 6.1.

4.4.4 Advance the borehole to the desired depth or target horizon where the sampling run is to begin. While drilling, monitor the breathing zone according to the project work plans and applicable drilling method SOP.

4.4.5 Connect the sampling tube to the drill rod string and advance the tube to the bottom of the boring. The tube is then pushed about 2 to 2.5 feet into the soil with a continuous, rapid motion without impact or twisting.

4.4.6 Pull the drill rod strip up from the bottom of the borehole and remove the sampling tube from the string. Observe and record the amount of sample recovery and any associated problems as discussed in Section 4.3.11.

4.4.7 Place teflon film over each end of the tube if it is to be submitted for chemical analysis and seal the ends with plastic end caps. Place custody tape over each end cap so that any attempt to remove the cap will break the tape. With a waterproof marker, write a "T" for top on the trailing end and a "B" for bottom on the leading end of the tube.

4.4.8 Appropriately label and number the tube as described in Section 4.3.14.

4.4.9 Document the sampling event on the Sample Collection Log (Attachment 6.2) as discussed in Section 4.3.15.

4.4.10 Appropriately preserve, package, handle and ship the sample in accordance with the procedures outlined in SOPs 20.1 and 2.1 and the project work plans. The samples shall also be maintained under custody per SOP 1.1. Samples stored on-site will be subject to the provisions of SOP 19.1.

4.4.11 Repeat this sampling procedure at the intervals specified in the project work plans until the bottom of the borehole is reached and/or last sample collected.

## **5.0 Records**

5.1 Records generated as a result of this SOP will be controlled and maintained in the project record files in accordance with SQP 4.2.

## **6.0 Attachments**

6.1 Visual Classification of Soils Form

## 6.2 Sample Collection Log

# LITHOLOGIC CLASSIFICATION

## FINE-GRAINED SOILS (Clay and Silts)

- I. TYPE
  - modifiers (approx. 15% or greater)
  - list from least to most abundant constituent
- II. GROUP SYMBOL
  - use United Soil Classification System
- III. COLOR
  - use Munsell color chart
- IV. MOISTURE CONTENT
- V. PLASTICITY
  - rolling into a thread test
- VI. CONSISTENCY/STRENGTH
  - rule-of-thumb test
  - blow counts
- VII. MISCELLANEOUS
  - fractures
  - roots, root openings
  - foreign staining
  - description of sand or gravel, if present
  - organic material
  - first water/static water levels
  - estimate of % of fines, sands, and gravels
  - degree of induration
  - odor

## II. UNITED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)		GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
				SW	WELL-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
FINE GRAINED SOILS	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)			SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
				ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAM CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
		LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, RICACIOUS OR BATHOGENOUS FINE SAND OR SILTY SOILS
HIGHLY ORGANIC SOILS	SILTS AND CLAYS			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
				PT	PEAT, MUDS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

FIGURAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

## COARSE-GRAINED SOILS (Sands and Gravels)

- I. TYPE
  - modifiers (approx. 15% or greater)
  - list from least to most abundant constituent
- II. GROUP SYMBOL
  - use United Soil Classification System
- III. COLOR
  - use Munsell color chart
- IV. MOISTURE CONTENT
- V. GRAIN SIZE AND DEGREE OF ANGULARITY
- VI. DEGREE OF DENSITY
  - blow counts
- VII. DEGREE OF GRADING
  - if a soil contains a wide range of grain sizes, the soil is well graded (poorly sorted)
- VIII. MISCELLANEOUS
  - fractures
  - roots, root openings
  - foreign staining
  - organic material
  - first water/static water levels
  - estimate of % of fines, sands, and gravels
  - odor

## V. GRAIN SIZE

Name	Size Limits	Familiar Example
Boulder	12in. or more	Larger than basketball
Cobbles	3in. - 12in.	Grapefruit
Coarse Gravel	3/4 - 1 inch - 3in.	Orange or lemon
Fine Gravel	4.75mm - 3/4in.	Grape or pea
Coarse Sand	2mm - 4.75mm	Rocksalt
Medium Sand	0.42mm - 2mm	Sugar, table salt
Fine Sand	0.075mm - 0.42mm	Powdered sugar
(Silt and/or Clay)	Less than 0.075mm	

## V. PLASTICITY

Results of rolling soil in fingers

Soil Type

Very weak thread or unable to form thread

Inorganic silt low plasticity (ML)

Weak spongy thread

Organic silt (OH) or inorganic silt with high liquid limit (MH)

Firm thread

Clay of medium plasticity (CL)

Rigid thread

Clay of high plasticity (CH)

## VI. CONSISTENCY/STRENGTH

Consistency Rule of Thumb Test

Very soft Core (height - twice diameter) sags under own weight

Soft Can be pinched in two between thumb and forefinger

Medium Stiff Can be imprinted easily with fingers

Stiff Can be imprinted with considerable pressure from fingers

Very Stiff Barely can be imprinted by pressure from fingers

Hard Cannot be imprinted by fingers

Blow Counts & Soil Classification - Clay

Blows/ft 3" O.D.	Description (Symbol)	Blows/ft 3" O.D.
0-2	Very Soft (V.S.)	0-2
3-4	Soft (So.)	3-4
5-9	Medium Stiff (M. Stf.)	5-9
10-19	Stiff (Stf.)	10-19
20-44	Very Stiff (V.Stf.)	20-44
45-70	Hard (Hd.)	45-70
70 +	Very Hard (V.Hd.)	70 +

\* Blows per foot after initial 6" penetration to drive a 2" or 3" O.D. sampler with 140-lb hammer falling 30" in the air

## III. COLOR

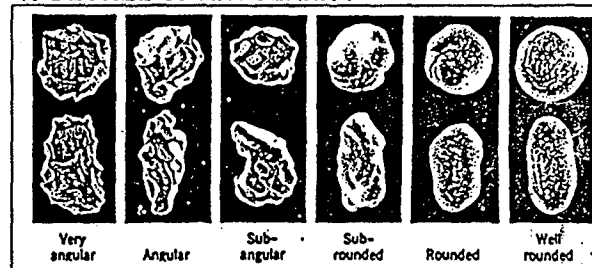
Hue, value, chroma 5Y 4/4

## IV. MOISTURE CONTENT

Descriptive terms:

Dry  
Slightly Moist  
Moist  
Wet  
Saturated

## V. DEGREE OF ANGULARITY

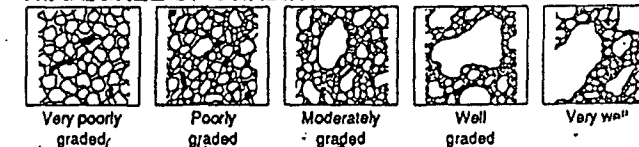


## VI. DEGREE OF DENSITY

Blows/ft 3" O.D.	Description (Symbol)	Blows/ft 3" O.D.
0-8	Very Loose (V.Ls.)	0-8
9-20	Loose (Lo.)	9-20
21-41	Medium Dense (M. Dns.)	21-41
42-80	Dense (Dns.)	42-80
80 +	Very Dense (V.Dns.)	80 +

\* Blows per foot after initial 6" penetration to drive a 2" or 3" O.D. sampler with 140-lb hammer falling 30" in the air

## VII. DEGREE OF GRADING





<b>COMMENTS:</b> (Continued)	<div style="border: 1px solid black; width: 100%; height: 100%; position: relative;"> <!-- Grid representation --> </div>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">DATE</td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> </tr> <tr> <td style="padding: 2px;">TIME</td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> </tr> <tr> <td style="padding: 2px;">PAGE ____ OF ____</td> <td colspan="7"></td> </tr> <tr> <td style="padding: 2px;">PAGE</td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> <td style="width: 10px;"></td> </tr> <tr> <td style="padding: 2px;">PROJECT NO.</td> <td colspan="7"></td> </tr> </table>	DATE								TIME								PAGE ____ OF ____								PAGE								PROJECT NO.							
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PREPARED BY: \_\_\_\_\_

**LEGEND**

1. A SAMPLE COLLECTION LOG IS TO BE COMPLETED FOR EACH SAMPLE.
  2. ALWAYS COMPLETE BOTH SIDES. IF SECOND SIDE IS NOT USED, DRAW A LINE THROUGH IT AND MARK N/A. FILL IN CONTROL BLOCK AND PREPARED BY.
  3. ALL ENTRIES ON LOG ARE TO BE COMPLETED. IF NOT APPLICABLE MARK N/A.
  4. DATE: USE MONTH/DAY/YEAR: I.E., 10/30/85
  5. TIME: USE 24-HOUR CLOCK; I.E., 1835 FOR 6:35 P M
  6. PAGE: EACH SAMPLE TEAM SHOULD NUMBER PAGE \_\_\_\_ OF \_\_\_\_ FOR THE DAY'S ACTIVITIES FOR ALL SHEETS PREPARED ON A SINGLE DAY. I.E., IF THERE ARE A TOTAL OF 24 PAGES (INCLUDING FRONT AND BACK) NUMBER 1 OF 24, 2 OF 24, ETC.
  7. SAMPLE LOCATION: USE BORING OR MONITORING WELL NUMBER, GRID LOCATION (TRANSECT), SAMPLING STATION I.D., OR COORDINATE TO PHYSICAL FEATURES WITH DISTANCES. INCLUDE SKETCH IN COMMENT SECTION IF NECESSARY.
  8. SAMPLE TYPE: USE THE FOLLOWING - SOIL, WATER (SURFACE OR GROUND), AIR (FILTERS, TUBES, AMBIENT, PERSONNEL), SLUDGE, DRUM CONTENTS, OIL, VEGETATION, WIPE, SEDIMENT
  9. COMPOSITE TYPE: I.E., 24-HOUR, LIST SAMPLE NUMBERS IN COMPOSITE, SPATIAL COMPOSITE.
  10. DEPTH OF SAMPLE. GIVE UNITS, WRITE OUT UNITS SUCH AS INCHES, FEET. DON'T USE " OR "
  11. WEATHER. APPROXIMATE TEMPERATURE, SUN AND MOISTURE CONDITIONS
  12. CONTAINERS USED. LIST EACH CONTAINER TYPE AS NUMBER, VOLUME, MATERIAL (E.G., 2 - 1L GLASS, 4 - 40 ML GLASS VIAL, 1 - 400 ML PLASTIC, 1 - 3 INCH STEEL TUBE, 1 - 8 OZ. GLASS JAR)
- AMOUNT COLLECTED VOLUME IN CONTAINERS (E.G. 1/2 FULL)

**FIGURE 7-2 (CONT'D)**

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## WATER LEVEL MEASUREMENTS IN MONITORING WELLS

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### STANDARD OPERATING PROCEDURE

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#### **1.0 Purpose**

This Standard Operating Procedure (SOP) establishes guidelines for personnel to use in determining the depth to water in monitoring wells.

#### **2.0 References**

2.1 EPA, 1986, RCRA Groundwater Monitoring Technical Enforcement Guidance Document, OSWER-9950.1, U.S. Government Printing Office, Washington, D.C.

2.2 EPA, 1991, Environmental Compliance Branch, Standard Operating Procedures and Quality Assurance Manual, Region IV, Environmental Services Division, Athens, Georgia, U.S. Government Printing Office, Washington, D.C.

2.3 SOP 5.1 - Nonaqueous Phase Liquid Measurements in Monitoring Wells

2.4 SOP 6.1 - Sampling Equipment and Well Material Decontamination

2.5 SQP 4.2 - Records Management

#### **3.0 Definitions**

None.

#### **4.0 Procedure**

Water level measurements are commonly taken in each monitoring well immediately prior to, during, and following well development, and both before and after well purging and sampling. Water level measurements may also be taken where no development or purging is being conducted, strictly to monitor or generate water table or piezometric surfaces. When such measurements are made to monitor water table or piezometric surfaces, water levels in

all wells at a given site should be measured within a 24-hour maximum period whenever possible. When measuring wells for water for water table or potentiometric surface analysis, and if the contaminant history is known for each of the wells, it is advisable to monitor water levels beginning with the least contaminated wells first and progressing to the most contaminated wells last.

#### ***4.1 Responsibilities***

Compliance with this procedure is the responsibility of project management and field personnel.

4.1.1 The Delivery Order Manager is responsible for ensuring that monitoring well water level measurements are properly collected and documented. This will be accomplished by staff training and by maintaining quality assurance/quality control (QA/QC).

4.1.2 The Contractor Quality Control Manager (CQCM) individual is responsible for the periodic review of documentation generated as a result of this SOP and the periodic review and audit of field personnel as they perform the work. If problems arise, the CQCM is also responsible for verifying implementation of corrective action(s) (i.e., retraining personnel, additional review of work plans and SOPs, variances to requirements, and issuing nonconformances) and assuring through monitoring the continued implementation of stated corrective actions.

4.1.3 Field sampling personnel assigned to this task are responsible for the proper collection and documentation of the monitoring well water level measurements.

#### ***4.2 Equipment Selection***

A number of devices are available for the determination of water level measurements in monitoring wells. Those most commonly used and covered in this SOP include: steel tapes, electric sounders, and petroleum product probes. The equipment must be capable of recording a measurement to the accuracy required by the project plans.

Project data quality objectives and site characteristics must be taken into account when determining the water level measurement equipment to use. The total number of wells to be



measured, weather, tidal influences, pumping, and construction can all affect water level measurements. The project-specific work plans will identify the specific equipment to be used.

#### ***4.3 Determining Water Level Measurements in Monitoring Wells***

The standard procedure for determining depth to water is described below.

4.3.1 Calibrate all measuring devices according to the manufacturer's specifications. Measuring tapes should be checked a minimum of every six months against a surveyor's tape to determine if shrinking or stretching has occurred.

4.3.2 Prior to taking a water level measurement at each well, decontaminate the measuring device according to the procedures outlined in SOP 6.1. During decontamination, all measuring tapes should be inspected for kinks, cracks, or tears and, if present, repaired or replaced with undamaged equipment.

4.3.3 Visually inspect the well to ensure that it is undamaged, properly labelled and secured. Any damage or problems with the well head should be noted on the Field Activity Daily Log (FADL) (Attachment 6.1) and the site superintendent notified for repair or replacement of the equipment.

4.3.4 Uncap the well and monitor the air space immediately above the open casing per the project-specific health and safety plan. Observe if any air is flowing into or out of the casing. In the event such conditions are observed, they should be noted on the Water Level Measurement Form, Well Development Record, or Sampling Information Form (Attachments 6.2, 6.3, and 6.4, respectively) as appropriate. Lower the electric sounder or equivalent (product probe or steel tape) into the well until the water surface is encountered. If air is observed to be entering flowing out of the casing, the sounder should not be placed inside the well until the air flow stops and pressure equalizes.

4.3.5 Measure the distance from the water surface to the permanent reference point. For aboveground "stickup" completions, the reference point is usually a groove cut into the north side of the casing. If no permanent reference point is available for an aboveground

completion, measure from another permanently fixed structure or from ground level. The point of measurement should then be noted on the FADL and the appropriate form on which the water level is recorded. For flush mount completions, such as street boxes, the water level measurement should be referenced to a steel plate placed across the rim of the street box and over the casing. Any aboveground completions without permanent reference points or marks should be brought to the attention of the appropriate supervisory personnel per the project-specific work plans.

4.3.6 Collect measurements until two consecutive measurements are identical or within the specified tolerance of the project-specific work plans (usually 0.01 ft). Record all appropriate information on either the Water Level Measurement Form, Well Development Record, or the Sampling Information Form, depending upon the task being performed. At a minimum, the following information must be recorded:

- project name and number;
- unique well identification number;
- date and time of measurement collection;
- depth to water to the specified tolerance;
- weather conditions; and
- any problems encountered.

4.3.7 If product or other nonaqueous liquid is encountered, follow the procedures outlined in SOP 5.1.

4.3.8 Cap and relock the well.

## **5.0 Records**

5.1 Records generated as a result of this SOP will be controlled and maintained in the project records files in accordance with SQP 4.2.

## **6.0 Attachments**

6.1 Field Activity Daily Log

6.2 Water Level Measurement Form

6.3 Well Development Record

6.4 Sampling Information Form

Berkeley  
Environmental  
Restoration  
Center

Daily Log	DATE			
	NO			
	SHEET	OF		

## FIELD ACTIVITY DAILY LOG

PROJECT NAME		PROJECT NO.	
PROJECT ACTIVITY SUBJECT:			
DESCRIPTION OF DAILY ACTIVITIES AND EVENTS:			
VISITORS ON SITE:		CHANGE FROM PLANS AND SPECIFICATION, AND OTHER SPECIAL ORDERS AND IMPORTANT DECISIONS.	
WEATHER CONDITIONS:		IMPORT TELEPHONE CALLS:	
BERC PERSONNEL ON SITE			
SIGNATURE		DATE:	

FIGURE 6-3

## WATER-LEVEL MEASUREMENTS

**Project Name:**

**Project No.:**

**Field Personnel:**

Date:

**General Observations:**

[illegible]

**SOP NO. 5.0**

**ATTACHMENT 6.3 – WELL DEVELOPMENT  
RECORD**

**PILOT-SCALE TREATIBILITY WORK PLAN**

**THE ABOVE IDENTIFIED ATTACHMENT IS NOT  
AVAILABLE.**

**EXTENSIVE RESEARCH WAS PERFORMED BY  
NAVFAC SOUTHWEST TO LOCATE THIS  
ATTACHMENT. THIS PAGE HAS BEEN INSERTED  
AS A PLACEHOLDER AND WILL BE REPLACED  
SHOULD THE MISSING ITEM BE LOCATED.**

**QUESTIONS MAY BE DIRECTED TO:**

**DIANE C. SILVA  
RECORDS MANAGEMENT SPECIALIST  
NAVAL FACILITIES ENGINEERING COMMAND  
SOUTHWEST  
1220 PACIFIC HIGHWAY  
SAN DIEGO, CA 92132**

**TELEPHONE: (619) 532-3676**

Date: \_\_\_\_\_

**Sample No.:** \_\_\_\_\_

☐ **FB:**\_\_\_\_\_

☐ DUP: \_\_\_\_\_

**Sampling Method:** \_\_\_\_\_

☐ Disposable Bailer

**Teflon Bailer**

☐ \_\_\_\_\_  
(Other)

### Number and Types of Bottle used

☐ Courier \_\_\_\_\_

☐ Hand Deliver:

Well Diameter: \_\_\_\_\_

☐ 2" (0.16 Gallon/Feet)

☐ 4" (0.65 Gallon/Feet

☐ 5" (1.02 Gallon/Feet)

☐ 6" (1.47 Gallon/Feet)

80% DTW\_\_\_\_\_

WTR QI TV SMPING INEO 2111 MBYI

**Comments:** \_\_\_\_\_

(Recommended Method For Purging Well)

---

## NONAQUEOUS PHASE LIQUID MEASUREMENT IN MONITORING WELLS

---

### STANDARD OPERATING PROCEDURE

---

#### **1.0 Purpose**

This Standard Operating Procedure (SOP) establishes guidelines for field personnel to use in determining the thickness of nonaqueous phase liquid in monitoring wells. The details within this SOP should also be used in conjunction with project work plans.

#### **2.0 References**

2.1 EPA, 1986, RCRA Groundwater Monitoring Technical Enforcement Guidance Document, OSWER-9950.1, U.S. Government Printing Office, Washington, D.C.

2.2 EPA, 1991, Environmental Compliance Branch, Standard Operating Procedures and Quality Assurance Manual, Region IV, Environmental Services Division, Athens, Georgia, U.S. Government Printing Office, Washington, D.C.

2.3 SQP 4.2 - Records Management

2.4 SOP 6.1 - Sampling Equipment and Well Material Decontamination

#### **3.0 Definitions**

3.1 Product - for the purposes of this procedure, product refers to liquid that is petroleum based (e.g., gasoline, diesel, or petroleum byproducts) or chlorinated hydrocarbon based (e.g., trichloroethene, tetrachloroethene, etc.).



## **4.0 Procedure**

### **4.1 Responsibilities**

4.1.1 The Project Manager is responsible for ensuring that nonaqueous phase liquid in monitoring wells is properly measured and documented. This will be accomplished by staff training and by maintaining quality assurance/quality control (QA/QC).

4.1.2 The Contractor Quality Control Manager (CQCM) is responsible for the periodic review of documentation associated with this SOP and the periodic review and audit of field personnel as they perform the work. If perceived variances occur, the CQCM is also responsible for issuing notices of nonconformance and requests for corrective action.

4.1.3 Field sampling personnel are responsible for the proper measurement and documentation of the nonaqueous phase liquid measurement in monitoring wells.

### **4.2 Equipment Selection**

4.2.1 This procedure addresses the operation of two types of equipment used to measure nonaqueous phase liquids (NAPLs) in monitoring wells: product probes and clear bailers. Clear bailers include both single- and double-check valve bailers. Single check valve bailers can only be used for measuring light nonaqueous phase liquids (LNAPLs) or floating products. Double check valve bailers can be used for measuring both LNAPLs and dense nonaqueous phase liquids (DNAPLs) or sinking product. The equipment must be capable of recording a measurement to an accuracy of 0.01 foot.

4.2.2 Several problems can arise in measuring product thickness with either product probes or clear bailers. Product probes can malfunction, particularly when measuring degraded or weathered product that sticks to the probe sensors. When the thickness of the product layer in a well is greater than the length of the bailer, the product layer cannot be accurately measured with the bailer. Consequently, it is recommended that both methods be used (one to check the other) to measure product thicknesses in wells. The project work plans will identify the specific equipment to be used.

### **4.3 Product Probe Procedure**

4.3.1 The product probe, sometimes called an immiscible layer probe, is a device that can detect the presence of both LNAPLs and DNAPLs (both "floating" and "sinking" layers) in water wells. The device detects the difference in conductivity or specific gravity between the aqueous and nonaqueous phases in the well. The device is generally a probe connected to a measuring tape with a reel. The device contains a receiver with an audio and/or visual signal that indicates when phase changes occur. The standard procedure for using a petroleum product probe is described below.

4.3.2 Check the accuracy of the measuring tape of the petroleum product probe according to the manufacturer's specifications. Measuring tapes should be checked at least every six months against a surveyor's tape to determine if shrinking or stretching has occurred.

4.3.3 Prior to taking a measurement and between wells, decontaminate the probe and tape measure according to the procedures outlined in SOP 6.1. It is extremely important to conduct thorough decontamination to prevent cross-contamination between wells. During decontamination, all measuring tapes should be inspected for kinks, cracks, or tears and, if present, repaired or replaced with undamaged equipment.

4.3.4 Visually inspect the well to ensure that it is undamaged, properly labelled and secured. Any damage or problems with the well head should be noted on the Field Activity Daily Log (FADL) (Attachment 6.1) and notify the site superintendent per the project work plans.

4.3.5 Uncap the well and monitor the air space immediately above the open casing per the Project Health and Safety Plan. Observe if any air is flowing into or out of the casing. In the event such conditions are observed, they should be noted on the Water Level Measurement Form, Well Development Form, or Sampling Information Form (Attachments 6.2, 6.3, and 6.4, respectively) as appropriate. If air is observed to be flowing into or out of the casing, the probe should not be placed inside the well until the air flow stops and pressure equalizes. Lower the probe into the well until the liquid surface is encountered. Continue lowering the probe, recording the depths at which any audio or visual changes in the device indicate a phase change. When measuring for DNAPL, continue

lowering the probe to the bottom of the well. When measuring for LNAPL, there is no need to lower the probe further once the product/water interface is encountered and measured.

4.3.6 While lowering the probe, measure the distances to the encountered phase/phases from the permanent reference point. For aboveground "stick-up" completions, the reference point is usually a groove cut into the north side of the casing. If no permanent reference point is available for an aboveground completion, measure from another permanently fixed structure or from ground level. The point of measurement should then be noted on the FADL and the appropriate form on which the water level is recorded.

For flush mount completions, such as street boxes, the water level measurement should be referenced to a steel rule placed across the rim of the street box and over the casing. Any aboveground completions without permanent reference points or marks should be brought to the attention of the site supervisor per the project work plans.

4.3.7 Collect measurements until two consecutive measurements are identical or within tolerances specified in the project work plans. Record all appropriate information on either the Water Level Measurement Form, Well Development Record, or the Sampling Information Form, depending upon the task being performed. At a minimum, the following information must be recorded:

- project name and number;
- well identification number;
- date and time of measurement collection;
- depth to water to the specified tolerance;
- depth to and description of any nonaqueous phase liquid encountered;
- weather conditions; and
- comments, including any problems encountered.

4.3.8 Cap and relock the well.

#### **4.4 Bailer Procedure**

4.4.1 A single check-valve bailer is a cylindrical tube, open at the top and containing a floating ball at the bottom. Lowering the bailer into liquid allows the bottom ball to float,

allowing floating product or water to enter the bailer. The design of this type of bailer only allows collection of a floating product (LNAPL) sample.

4.4.2 A double check-valve bailer is an enclosed cylindrical tube containing a floating ball at both the top and the bottom. Lowering the bailer into liquid causes both balls to float allowing water or product to enter the cylinder. Raising the bailer through the water causes both balls to settle, effectively trapping a discrete section of the water so that it can be brought to the surface. Since the double check-valve bailer is capable of collecting a discrete sample at any depth within the well, it can be used on both "floating" and "sinking" nonaqueous liquids.

4.4.3 The bailers must be constructed of clear material so that any product can be visibly measured. Some are also available with graduated markings on the side to allow easier measurement. The standard procedure for using bailers to measure nonaqueous phase liquids in monitoring wells is described below.

Bailers are commonly used with a thin nylon line or "chord" made of similar material. Some are supplied with a connectable measuring tape.

4.4.4 Check the accuracy of the measuring tape to be used with the bailer according to the manufacturer's specifications. Measuring tapes should be checked a minimum of every six months against a surveyor's tape to determine if shrinking or stretching has occurred.

4.4.5 Prior to taking a measurement and between wells, decontaminate the bailer and tape measure according to the procedures outlined in SOP 6.1, Sampling Equipment and Well Material Decontamination. If a bailer line is used, it is advised to slip, cut, and dispose of any. The run inside a previous well and then decontaminate the remaining line. Bailers used for product sampling should never be used for purging or collecting water samples.

4.4.6 If product probe measurements are to be used in conjunction with a bailer, the probe measurements should first be made, recorded, and noted by field personnel taking the measurements.

4.4.7 If bailer measurements are to be taken before or without product probe measurements, visually inspect and document well head conditions per 4.3.4 above. Uncap the well and monitor and observe the well head per 4.3.5 above.

4.4.8 Lower the bailer into the well until the liquid surface is encountered. Use the measuring tape if available to determine the depth to which the bailer should be lowered to recover either the LNAPL or DNAPL product.

If using bailer chord and attempting to recover DNAPL ("sticking") product, a double check-valve bailer may simply be run to the bottom of the well. If attempting to recover LNAPL ("floating") product using bailer chord, it is advisable to first note the depths to product and water made with the product probe and mark the depths on the bailer chord with a rubber band or twine. The bailer (either single or double check-valve) should then be lowered such that the bailer retrieves product and does not run completely through the product layer, thereby retrieving only water.

If no product probe measurements are available, the person attempting to retrieve the bailer product sample will then have to "feel" for first contact with the liquid while the bailer is descending inside the well. Once the contact is felt, the bailer descent should be halted. The bailer should then be slowly lowered no more than  $\frac{3}{4}$  of its total length to avoid overtopping. Retrieve the bailer and visually inspect for product. Measure the amount of product contained in the bailer with the measuring tape. Note any appropriate conditions observed in the bailer such as:

- Color and clarity of the product
- Length of product column in bailer compared to overall length of bailer
- Evidence of any problems with the bailer valves
- Evidence of overtopping or complete run through the product column.

4.4.9 Record all appropriate information on either the Water Level Measurement Form, Well Development Record, or the Sampling Information Form, depending upon the task being performed. At a minimum, the following information must be recorded:

- project name and number;
- well identification number;
- date and time of measurement collection;
- depth to water if available to the appropriate tolerance specified in the project work plans;
- measurement and description of any nonaqueous phase liquid encountered;
- any observations made in 4.3.5 above; and
- comments, including any problems encountered.

4.4.10 Cap and relock the well.

## ***5.0 Records***

Records generated as a result of this SOP will be controlled and maintained in the project record files in accordance with SQP 4.2.

## ***6.0 Attachments***

- 6.1 Field Activity Daily Log
- 6.2 Water Level Measurement Form
- 6.3 Well Development Record
- 6.4 Sampling Information Form

Berkeley  
Environmental  
Restoration  
Center

Daily Log	DATE			
	NO			
	SHEET	OF		

## FIELD ACTIVITY DAILY LOG

PROJECT NAME		PROJECT NO.
PROJECT ACTIVITY SUBJECT:		
DESCRIPTION OF DAILY ACTIVITIES AND EVENTS:		
VISITORS ON SITE:		CHANGE FROM PLANS AND SPECIFICATION, AND OTHER SPECIAL ORDERS AND IMPORTANT DECISIONS.
WEATHER CONDITIONS:		IMPORT TELEPHONE CALLS:
BERC PERSONNEL ON SITE		
SIGNATURE		DATE:

FIGURE 6-3

# WATER-LEVEL MEASUREMENTS

**Project Name:**

**Project No.:**

**Field Personnel:**

Date:

**General Observations:**

[illegible]



SOP NO. 5.2

ATTACHMENT 6.3 – WELL DEVELOPMENT  
RECORD

PILOT-SCALE TREATIBILITY WORK PLAN

THE ABOVE IDENTIFIED ATTACHMENT IS NOT  
AVAILABLE.

EXTENSIVE RESEARCH WAS PERFORMED BY  
NAVFAC SOUTHWEST TO LOCATE THIS  
ATTACHMENT. THIS PAGE HAS BEEN INSERTED  
AS A PLACEHOLDER AND WILL BE REPLACED  
SHOULD THE MISSING ITEM BE LOCATED.

QUESTIONS MAY BE DIRECTED TO:

**DIANE C. SILVA**  
**RECORDS MANAGEMENT SPECIALIST**  
**NAVAL FACILITIES ENGINEERING COMMAND**  
**SOUTHWEST**  
**1220 PACIFIC HIGHWAY**  
**SAN DIEGO, CA 92132**

**TELEPHONE: (619) 532-3676**

Date: \_\_\_\_\_

Sample No.: \_\_\_\_\_

☐ **FB:**\_\_\_\_\_

☐ DUP: \_\_\_\_\_

**Sampling Method:** \_\_\_\_\_

☐ Disposable Bailer

☐ Teflon Bailer

□ \_\_\_\_\_

(Other)

### Number and Types of Bottle used

☐ Courier \_\_\_\_\_

(Lab Name)

☐ Hand Deliver:

Well Number: \_\_\_\_\_

Well Diameter: \_\_\_\_\_

Depth of Water: \_\_\_\_\_

☐ 2" (0.16 Gallon/Feet)

Well Depth: \_\_\_\_\_

☐ 4" (0.65 Gallon/Feet)

Height of Water Column: \_\_\_\_\_

☐ 5" (1.02 Gallon/Feet)

**Volume in Well:**\_\_\_\_\_

☐ 6" (1.47 Gallon/Feet)

80% DTW\_\_\_\_\_

WTR QLTY: SMPLNG INFO: 22 JUN 94 RYL

Inlet Depth: \_\_\_\_\_

**Comments:**

(Recommended Method For Purging Well)

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## DRILLING, DEVELOPMENT, AND HEAVY EQUIPMENT DECONTAMINATION

---

### STANDARD OPERATING PROCEDURE

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#### **1.0 Purpose**

This Standard Operating Procedure (SOP) establishes guidelines for use by field personnel in the decontamination of drilling, development, and heavy equipment. The details within this SOP are applicable as general requirements for drilling and heavy equipment decontamination, and should also be used in conjunction with project work plans.

#### **2.0 References**

2.1 EPA, September 1987, EPA Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidelines for Conducting Remedial Investigation and Feasibility Studies under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.3 SQP 4.2 - Records Management

2.4 SOP 6.1 - Sampling Equipment and Well Material Decontamination

#### **3.0 Definitions**

3.1 Laboratory Grade Detergent - A standard brand of laboratory-grade detergent, such as "Alconox" or "Liquinox."

3.2 Potable Water - Water dispensed from a municipal water system.

## **4.0 Procedure**

### **4.1 Responsibilities**

4.1.1 Compliance with this procedure is the responsibility of project management and field personnel. This SOP and the project work plans should be reviewed before implementing drilling, development, and heavy equipment decontamination at the project field area.

4.1.2 The Project Manager has the responsibility for ensuring that the decontamination of drilling and heavy equipment is properly performed through staff training and by maintaining quality assurance/quality control (QA/QC).

4.1.3 The Contractor Quality Control Manager (CQCM) has the responsibility for periodic review of procedures and documentation associated with the decontamination of drilling and heavy equipment. If perceived variances occur, the CQCM is also responsible for issuing notices of nonconformances and requesting corrective actions. Additionally, he/she will perform the three phases of inspections and continuous monitoring of the decontamination activities.

4.1.4 The project staff assigned to drilling, development, trenching, or construction activities are responsible for ensuring that subcontractors or equipment operators properly decontaminate the drilling, development, and heavy equipment associated with those tasks. The project staff are also responsible for documenting the decontamination activities on the Field Activity Daily Log (FADL) (Attachment 6.1) and/or appropriate form(s) as specified in the project work plans.

### **4.2 General**

4.2.1 This section provides requirements for the set up of a decontamination facility for drilling, development, and heavy equipment and the decontamination procedures to be followed. The project work plans will provide specific information regarding:

- Types of equipment requiring decontamination under this SOP;
- Location of the decontamination station;

- Types and/or specifications on materials to be used in the fabrication of the decontamination station; and
- Types of materials and additional details on the procedures to be used in the decontamination process.

4.2.2 All field personnel associated with either the fabrication of the decontamination station or the decontamination of drilling or heavy equipment must read both this SOP and the project work plans prior to implementation of related decontamination activities. Information and requirements for the decontamination of any and all equipment used specifically for sampling is presented in SOP 6.1.

#### ***4.3 Decontamination Facility***

4.3.1 A decontamination station will be set up in an area exclusively for decontamination of drilling, well development, and/or heavy equipment. The location of the decontamination station will be specified in the project work plans. All decontamination of drilling, development, and heavy equipment will be conducted within the station.

4.3.2 At a minimum, the station will be constructed such that all rinsates, liquid spray, soil, debris, and other decontamination wastes are fully contained and may be collected for appropriate waste management and disposal. The station may be as simple as a bermed, impermeable polyethylene sheeting, of sufficient thickness, with an impermeable sump for collecting rinse water. More sophisticated designs involving self-contained metal decontamination pads in combination with bermed polyethylene sheeting may also be used, depending on project-specific requirements. These requirements along with specific equipment and construction specifications for the decontamination station will be provided in the project work plans.

#### ***4.4 Decontamination of Downhole Equipment***

4.4.1 All downhole drilling and development equipment (including but not limited to drill pipe, drive casing, drill rods, bits, tools, bailers, etc.) will be thoroughly decontaminated before mobilization onto each site and between borings or wells at each site or as required in the project work plans. The standard procedure will be performed as described below. Decontamination will be performed in accordance with this SOP and the project work plans.

4.4.2 Appropriate personal protective equipment (as specified in the project work plans) must be worn by all personnel involved with the task to limit personal exposure.

4.4.3 Equipment caked with drill cuttings, soil, or other material will initially be scraped or brushed. The scrapings will be containerized and appropriately disposed.

4.4.4 Equipment will then be sprayed with potable water using a hot water, high pressure washer.

4.4.5 Washed equipment will then be rinsed with potable water.

4.4.6 Decontaminated downhole equipment (such as drill pipe, drive casing, bits, tools, bailers, etc.) will be placed on clean plastic sheeting to prevent contact with contaminated soil and allowed to air dry. If equipment is not used immediately, it will be covered or wrapped in plastic sheeting to minimize airborne contamination.

4.4.7 Decontamination activities will be documented by the Site Superintendent, lead geologist, or lead engineer on the FADL and/or appropriate form(s), as specified in the project work plans.

#### ***4.5 Decontamination of Heavy Equipment***

4.5.1 Heavy equipment (e.g., drill rigs, development rigs, backhoes, and other earthmoving equipment) will be decontaminated between drilling sites or inside the contaminant reduction area prior to entering and leaving an exclusion zone. Decontamination will be performed in accordance with the project work plans. The standard procedure will be performed as described below.

4.5.1.1 Appropriate personal protective equipment (as specified in the project work plans) will be worn by all personnel involved in the task, in order to limit personal exposure.

4.5.1.2 Equipment caked with drill cuttings, soil, or other material will be initially scraped or brushed. The scrapings will be containerized and appropriately disposed.

4.5.1.3 Equipment will then be sprayed with potable water using a hot water, high pressure washer.

4.5.1.4 Clean equipment will then be rinsed with potable water.

4.5.2 During the decontamination effort, fluid systems should be inspected for any leaks or problems which might potentially result in an inadvertent release at the site, thereby contributing to the volume of waste or contamination. Any identified problems should be immediately repaired and documented on the FADL. Decontamination should then be completed before moving the equipment onto the site or exclusion zone.

4.5.3 Decontamination activities will be documented by the Site Superintendent, lead geologist, or lead engineer on the FADL and/or appropriate form(s), as specified in the project work plans.

4.5.4 Between boreholes at the same site, the back-end of the drilling rigs will be washed with potable water until surfaces are visibly free of soil buildup.

## **5.0 Records**

Records generated as a result of implementation of this SOP will be controlled and maintained in the project record files in accordance with SQP 4.2.

## **6.0 Attachments**

6.1 Field Activity Daily Log.

Berkeley  
Environmental  
Restoration  
Center

Daily Log	DATE			
	NO			
	SHEET		OF	

## FIELD ACTIVITY DAILY LOG

PROJECT NAME		PROJECT NO.	
PROJECT ACTIVITY SUBJECT:			
DESCRIPTION OF DAILY ACTIVITIES AND EVENTS:			
VISITORS ON SITE:		CHANGE FROM PLANS AND SPECIFICATION, AND OTHER SPECIAL ORDERS AND IMPORTANT DECISIONS.	
WEATHER CONDITIONS:		IMPORT TELEPHONE CALLS:	
BERC PERSONNEL ON SITE			
SIGNATURE		DATE:	

FIGURE 6-3



---

# MONITORING WELL INSTALLATION

---

## STANDARD OPERATING PROCEDURE

---

### **1.0 Purpose**

This Standard Operating Procedure (SOP) provides procedures and requirements for the installation of monitoring wells using rotary, dual-tube percussion, or hollow-stem auger drilling techniques. The details within this SOP should be used in conjunction with specific project work plans.

### **2.0 References**

2.1 U.S. Environmental Protection Agency (EPA), Manual of Water Well Construction Practices, U.S. Environmental Protection Agency, Office of Water Supply, U.S. Government Printing Office, Washington D.C.

2.2 U.S. Environmental Protection Agency (EPA), 1986, Resource Conservation and Recovery Act (RCRA) Ground Monitoring Technical Enforcement Guidance Document, OSWER-9950.1, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, U.S. Government Printing Office, Washington D.C.

2.3 U.S. Environmental Protection Agency (EPA), 1987, A Compendium of Superfund Field Operations Methods, EPA-500/P-87/001, U.S. Government Printing Office, Washington D.C.

2.4 SOP 6.1 - Sampling Equipment and Well Material Decontamination

2.5 SOP 6.2 - Drilling and Heavy Equipment Decontamination

2.6 SOP 14.1 - Hollow Stem Auger Drilling

2.7 SOP 14.2 - Mud Rotary Drilling

2.8 SOP 14.3 - Air Rotary Drilling

2.9 SOP 14.4 - Dual Tube Percussion Drilling

2.10 SOP 15.1 - Lithologic Logging

2.11 SOP 16.1 - Filter Pack and Well Screen Slot Size Determination

2.12 SQP 4.2 - Records Management

2.13 SQP 8.2 - Calibration and Maintenance of Measuring and Test Equipment

### **3.0 Definitions**

#### **3.1 Cuttings**

Pieces of soil, sediment, or rock cut by a bit in the process of drilling borings.

#### **3.2 Borehole**

Any hole drilled into the subsurface for the purpose of identifying lithology, collecting soil samples, and/or installing groundwater wells.

#### **3.3 Grout**

For the purposes of this SOP, the term "grout" consists of a neat cement grout generally containing three to five percent bentonite powder to water by weight. The grout is emplaced as a slurry, and once properly set and cured, is capable of restricting movement of water.

#### **3.4 Hollow-Stem Auger Drilling**

A drilling method using augers with open centers. The augers are advanced with a screwing or rotating motion into the ground. Cuttings are brought to the surface by the rotating action of the augers, thereby clearing the borehole.

### **3.5 Air Rotary Casing Hammer Drilling**

A drilling method using a nonrotating drive casing that is advanced simultaneously with a slightly smaller diameter rotary bit attached to a string of drill pipe. The drive casing is a heavy-walled, threaded pipe that allows for pass-through of the rotary drill bit inside the center of the casing. Air is forced down through the center drill pipe to the bit, and then upward through the space between the drive casing and the drill pipe. The upward return stream removes cuttings from the bottom of the borehole.

### **3.6 Mud Rotary Drilling**

For the purposes of this monitoring well installation SOP, the term "mud rotary drilling" refers to direct circulation (as opposed to reverse circulation) mud rotary drilling. Mud rotary drilling uses a rotating drill bit which is attached to the lower end of a string of drill pipe. Drilling mud is pumped down through the inside of the drill pipe and out through the bit. The mud then flows upward in the annular space between the borehole and the drill pipe, carrying the cuttings in suspension to the surface.

### **3.7 Dual-tube Percussion Drilling**

A drilling method using nonrotating drive casing with a bit on the bottom of the casing string. A smaller diameter tube or drill pipe is positioned inside the drive casing. The drive casing is advanced by the use of a percussion hammer, thereby causing the bit to cut or break up the sediment or soil at the bottom of the boring. Air is forced down the annular space between the drive casing and inner drill pipe and cuttings are forced up the center of the inner drill pipe.

### **3.8 Monitoring Well**

A well that provides for the collection of representative groundwater samples, the detection and collection of representative light and dense nonaqueous phase organic liquids, and the measurement of fluid levels.

### **3.9 Annular Space**

The space between:

- Concentric drill pipes;
- An inner drill pipe and outer drive casing;

- Drill pipe or drive casing and the borehole wall; or
- Well screen or casing and the borehole wall.

### **3.10 Filter Pack**

Granular filter material (sand, gravel, etc.) placed in the annular space between the well screen and the borehole to increase the effective diameter of the well and prevent fine-grained material from entering the well.

### **3.11 Well Screen**

A perforated, wire wound, continuous wrap or slotted casing segment used in a well to maximize the entry of water from the producing zone and to minimize the entrance of sand.

### **3.12 Tremie**

A tubular device or pipe used to place grout, bentonite, or filter pack in the annular space.

## **4.0 Procedure**

This section contains both main responsibilities and procedures for monitoring well installation activities. The procedures described herein are applicable as requirements for monitoring well installations using mud rotary, air rotary, air rotary casing hammer, dual tube percussion, or hollow-stem auger drilling techniques. Site-specific factors need to be considered in the selection of well construction and completion materials, specification of well designs, and choosing well drilling methods. These factors will be incorporated in project planning activities and the compilation of specific project work plans. The project work plans will contain the following information related to monitoring well installation:

- Objectives of the monitoring well
- Specific location of the well to be installed
- Zone or depth well is to be installed
- Drilling method(s) to be used
- Well construction materials to be used

- Specification of well design(s) including Well Construction Diagrams (Attachment 6.1)
- Additional procedures or requirements beyond this SOP.

#### **4.1 Responsibilities**

4.1.1 The Delivery Order Manager is responsible for ensuring that all monitoring well installation activities are conducted and documented in accordance with this and any other appropriate procedures. This will be accomplished through staff training and by quality assurance/quality control (QA/QC) monitoring activities.

4.1.2 The Contractor Quality Control Manager (CQCM) is responsible for periodic review of well installation activities to assure implementation of this SOP. The CQCM is also responsible for the review and approval of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to monitoring well installation requirements, issuing nonconformances, etc.) identified during the performance of these activities.

4.1.3 Field personnel assigned to monitoring well installation activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from the procedures to the Site Superintendent, Project Manager, or the CQCM.

#### **4.2 Well Installation Procedures**

4.2.1 Before mobilization of a rig to the well site, ensure that the monitoring well location has been appropriately cleared of all underground utilities, buried objects, and drill permits have been issued per the project work plans. Review all forms and diagrams documenting the location of the cleared monitoring well site and the location of any identified underground utility lines or other buried objects.

4.2.2 Decontaminate all downhole equipment and well construction materials before monitoring well installation, as described in SOP 6.1. Decontaminate the drilling rig and all drilling equipment before monitoring well installation per SOP 6.2.

4.2.3 Clear the work site of all brush and minor obstructions and then mobilize the rig to the monitoring well location. The rig geologist or engineer should then review with the driller the proposed well design and details of the well installation including any anticipated potential drilling or completion problems.

4.2.4 Calibrate health and safety monitoring equipment according to the instrument manufacturer's specifications. Document the calibration results on the appropriate form(s), as specified by SQP 8.2. Instruments that cannot be calibrated according to the manufacturer's specifications will be removed from service and tagged.

4.2.5 Workers will be provided with, and don, the appropriate personal protective equipment as specified by the project work plans. Typically, the minimum personal protection will include a hard hat, safety glasses, gloves, steel-toed boots, hearing protection, and coveralls.

4.2.6 Commence drilling and advance the borehole while conducting health and safety monitoring according to the project work plans. Perform readings as often as necessary to ensure the safety of workers. Record all measurements on the Field Activity Daily Log (FADL) (Attachment 6.2) and/or other appropriate form(s) as specified in the project work plans. Record all other pertinent information (date, site, well or boring number, and location) on the FADL and/or on other appropriate form(s) as specified by the project work plans. Also note and record observed field conditions, any unusual circumstances, and weather conditions. Drilling of the borehole should be conducted in conformance with SOPs 14.1, 14.2, 14.3, or 14.4, as appropriate.

4.2.7 During drilling, collect representative cutting and soil samples as required by the project work plans. Compile a boring or lithologic log from the cuttings and samples per SOP 15.1.

4.2.8 At total depth, remove soil cuttings through circulation or rapidly spinning the augers prior to constructing the well. Review logs and notes with the driller for any zones or depths exhibiting drilling problems which may affect the well installation. Condition the hole or take other actions mutually agreed upon by the rig geologist (or engineer), lead technical personnel, and the driller to ensure or aid in the well development.

4.2.9 Remove the drill pipe and bit if using rotary techniques, or remove the center bit boring if using the hollow-stem auger technique. The well construction materials will then be installed inside the open borehole or through the center of the drive casing or augers.

4.2.10 Measure the total depth of the completed boring using a weighted sounding line. The borehole depth is checked to assure that formation material has not heaved to fill the borehole. If heaving has taken place, options for cleaning, redrilling, or installation in the open section of the boring should be discussed with lead technical personnel.

4.2.11 In the event that the hole was over-drilled, grout, bentonite pellets, or bentonite chips (as specified in the project work plans) may be added to the bottom of the boring to raise the bottom of the hole to the desired depth. The grout should be pumped through a tremie pipe and fill from the bottom of the boring upward. During grouting, the tremie pipe should be submerged below the top of the grout column in the borehole to prevent free-fall and bridging. If bentonite is used, it should be added gradually to prevent bridging. Grout or bentonite addition will stop when its level has reached approximately one foot below the desired base of the well string (casing, screen, end plug or sump, etc.). The bentonite plug will be hydrated for at least one hour before installation of a filter pack.

4.2.12 Calculate volumes of filter pack, bentonite pellets/slurry, and grout required, based on borehole and well casing dimensions. If required by the project work plans, determine the filter pack and well screen slot size for the monitoring well per SOP 16.1.

4.2.13 Place a layer of filter pack (one to two feet, unless otherwise specified in the project-specific work plans) at the bottom of the borehole. The filter pack will be installed through the center of the drive casing/augers. Filter pack will be added slowly while withdrawing the drive casing/augers.

4.2.14 Inspect the casing, screen, and any other well construction materials prior to installation to assure that no damage has occurred during shipment and decontamination activities.

4.2.15 Connect and carefully lower the well string through the open borehole, drive casing, or inside of the augers until the well string is at the desired depth. The well string should be suspended by the installation rig and should not rest on the bottom of the boring. In the event the well string was dropped, lowered abruptly, or for any other reason suspected of being damaged during placement, the string should be removed from the boring and inspected. In certain instances, the well string may rise after being placed in the borehole due to heaving sands. If this occurs, the driller must not place any drilling equipment (drill pipe, hammers, etc.) to prevent the casing from rising. The amount of rise should be noted by the rig geologist or engineer who should then consult lead technical personnel for an appropriate course of action.

4.2.16 Record the following information on the Well Completion Form (Attachment 6.3) and/or other appropriate forms per the project work plans:

- Length of well screen
- Total depth of well boring
- Depth from ground surface to top of grout or bentonite plug in bottom of borehole (if present)
- Depth to base of well string
- Depth to top and bottom of well screen.

4.2.17 When using the mud rotary drilling technique, tremie the filter pack into the annular space around the screen. Clean, potable water may be used to assist with the filter pack tremie operation. For all other drilling techniques, the filter pack may be allowed to free fall or be tremied per the project work plans. If using drive casing or augers, the drive casing or augers should be pulled slowly during filter pack installation in increments no greater than five feet.

4.2.18 Filter pack settlement should be monitored by initially measuring the sand level (before beginning to withdraw the drive casing/augers). In addition, depth soundings using a weighted tape shall be taken repeatedly to continually monitor the level of the sand. The top of the well casing shall also be monitored to detect any movement due to settlement or from drive casing/auger removal. If the top of the well casing moves upwards at any time during the well



installation process, the driller should not be allowed to set drilling equipment (downhole hammers, drill pipe, etc.) on the top of the casing to prevent further movement.

4.2.19 Filter pack should be added until its height is approximately two feet above the top of the screen (unless otherwise specified in the project work plans), and verification of its placement (by sounding) should be conducted. The filter pack should then be gently surged using a surge block or swab in order to settle the pack material and reduce the possibility of bridging.

4.2.20 The height of the filter pack will then be re-sounded and additional filter pack placed as necessary. Once the placement of the filter pack is completed, the depth to the top of the pack is measured and recorded on the Well Completion Form (Attachment 6.3) or other appropriate forms per the project work plans.

4.2.21 A three-foot thick (unless otherwise specified in the project work plans) bentonite seal is then installed on top of the filter pack. If pellets or chips are used, they should be added gradually to avoid bridging. Repeated depth soundings will be taken using a weighted tape to ascertain the top of the bentonite seal. The seal should be allowed to hydrate for at least one hour before proceeding with the grouting operation.

4.2.22 After hydration of the bentonite seal, grout is then pumped through a tremie pipe and filled from the top of the bentonite seal upward. The bottom of the tremie pipe should be maintained below the top of the grout to prevent free fall and bridging. When using drive casing or hollow-stem auger techniques, the drive casing/augers should be raised in incremental intervals, keeping the bottom of the drive casing/augers below the top of the grout. Grouting will cease when the grout level has risen to within approximately one to two feet of the ground surface, depending on the surface completion type (flush mount versus aboveground). Grout levels should be monitored to assure that grout taken into the formation is replaced by additional grout. If settling of the grout occurs, additional topping off of the grout may be necessary.

4.2.23 For aboveground completions, the protective steel casing will be centered on the well casing and inserted into the grouted annulus. Prior to installation, a 2-inch deep temporary

spacer shall be placed between the PVC well cap and the bottom of the protective casing cover to keep the protective casing from settling onto the well cap.

4.2.24 After the protective casing has set, a drainage hole may be drilled into the protective casing if required by the project work plans. The drainage hole is positioned approximately two inches above ground surface. The protective casing will be painted with a rust-preventive colored paint.

4.2.25 The well head will be labeled to identify, at a minimum, the well number, depth, and date of installation.

4.2.26 A minimum of 24 hours after grouting should elapse before installation of the concrete pad and steel guard posts for aboveground completions, or street boxes or vaults for flush mount completions.

4.2.27 For aboveground completions, a concrete pad, usually 3-foot by 3-foot by 4-inch thick, is constructed at ground surface around the protective steel casing. The concrete is sloped away from the protective casing to promote surface drainage from the well.

4.2.28 For aboveground completions, where traffic conditions warrant extra protection, three steel bucking posts will be embedded to a depth approximately 1.5 feet below the top of the concrete pad. The posts will be installed in concrete filled post holes spaced equally around the well at a distance of approximately 1.5 feet from the protective steel casing. Where removal of bucking posts is required for well access, mounting sleeves should be imbedded into the concrete.

4.2.29 For flush mount (or subgrade) completions, a street box or vault is set and cemented in position. The top of the street box or vault will be raised slightly above grade and the cement sloped to grade to promote surface drainage away from the well.

4.2.30 Following well completion and demobilization of the rig, the well site should be cleared of all debris and trash and restored to a neat and clean appearance per the project work plans. All

investigation-derived waste generated at the well site should be appropriately contained and managed per the project work plans.

## **5.0 Records**

Records generated as a result of implementation of this SOP will be controlled and maintained in the project record files in accordance with SQP 4.2.

## **6.0 Attachments**

- 6.1 Example Well Construction Diagram
- 6.2 Field Activity Daily Log
- 6.3 Example Well Completion Form

SOP NO. 8.1

ATTACHMENT 6.1 – EXAMPLE WELL  
CONSTRUCTION SUMMARY

PILOT-SCALE TREATIBILITY WORK PLAN

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**TELEPHONE: (619) 532-3676**

**Berkeley  
Environmental  
Restoration  
Center**

Daily Log	DATE			
	NO			
	SHEET	OF		

## FIELD ACTIVITY DAILY LOG

PROJECT NAME		PROJECT NO.	
PROJECT ACTIVITY SUBJECT:			
DESCRIPTION OF DAILY ACTIVITIES AND EVENTS:			
VISITORS ON SITE:		CHANGE FROM PLANS AND SPECIFICATION, AND OTHER SPECIAL ORDERS AND IMPORTANT DECISIONS.	
WEATHER CONDITIONS:		IMPORT TELEPHONE CALLS:	
BERC PERSONNEL ON SITE			
SIGNATURE		DATE:	

**FIGURE 6-3**

SOP NO. 8.1

ATTACHMENT 6.3 – EXAMPLE WELL  
COMPLETION FORM

PILOT-SCALE TREATIBILITY WORK PLAN

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## MONITORING WELL DEVELOPMENT

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### STANDARD OPERATING PROCEDURE

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#### **1.0 Purpose**

This Standard Operating Procedure (SOP) establishes guidelines for specifying, assessing and documenting the well development process. Additional specific well development procedures and requirements will be provided in the project work plans.

#### **2.0 References**

2.1 SOP 5.1 - Water Level Measurements in Monitoring wells

2.2 SOP 6.1 - Sampling Equipment and Well Material Decontamination

2.3 SOP 6.2 - Drilling and Heavy Equipment Decontamination

2.4 SQP 4.2 - Records Management

2.5 SQP 8.2 - Calibration and Maintenance of Measuring and Test Equipment

2.6 U.S. Environmental Protection Agency (EPA), August 1988, Guidance for Conducting Remedial Investigation and Feasibility Studies under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.7 U.S. Environmental Protection Agency (EPA), 1987, A Compendium of Superfund Field Operations Methods, EPA-540/P-87/001a, U.S. Government Printing Office, Washington D.C.

2.8 ASTM, 1988, Standards Technology Training Program - Groundwater and Vadose Zone Monitoring, Nielsen, et al.

### **3.0 Definitions**

3.1 Well Development - The act of removing fine grained sediment and drilling fluids from the sand pack and formation in the immediate vicinity of the well, thus increasing the porosity and permeability of the materials surrounding the intake portion of the well.

3.2 Educator Pipe - The pipe used to transport well discharge water to the surface.

### **4.0 Procedure**

#### **4.1 General**

4.1.1 The most common methods used to develop monitoring wells consist of surging and bailing, surging and pumping, or combinations of all these.

4.1.2 The project work plans will identify the specific well development procedure to be followed. The standard procedure for field personnel to use in assessing and documenting well development is described below and is intended only for development methods listed above.

#### **4.2 Responsibilities**

4.2.1 The Delivery Order Manager is responsible for ensuring that monitoring wells are properly developed and that the development process is properly documented. This will be accomplished by staff training and by maintaining quality assurance/quality control (QA/QC).

4.2.2 The Contractor Quality Control Manager (CQCM) is responsible for periodic review of field generated documentation associated with well development. If deviations from project requirements occur, the CQCM is also responsible for issuing notices of nonconformances and requests for corrective action.

4.2.3 Field personnel are responsible for conducting monitoring well development and documentation in accordance with the specifications outlined in this SOP and by the project work plans.



### **4.3 Well Development**

4.3.1 Decontaminate the rig and development equipment in accordance with SOPs 6.1 and 6.2, respectively.

4.3.2 Calibrate all field analytical test equipment (pH, temperature, conductivity, turbidity) according to the instrument manufacturer's specifications and SQP 8.2. Specific test equipment to be used should be identified in the project-specific work plans. Instruments that cannot be calibrated according to the manufacturer's specifications will be removed from service, tagged with an out of calibration label, and segregated (when possible) from the calibrated equipment area.

An exception to the daily calibration requirements will be made in the case of the water level meters. The tape of these instruments will be checked prior to the beginning of the project and each succeeding six months using a steel surveyor's tape.

4.3.3 Visually inspect the well to ensure that it is undamaged, properly labelled and secured. Any observed problems with the well head should be noted in the Field Activity Daily Log and reported to the Site Superintendent.

4.3.4 Unlock the well and obtain a depth to water level measurement according to the procedures outlined in SOP 5.1. Calculate the volume of water in the well (cased well volume) as follows:

$$\left(\frac{d}{2}\right)^2 \times (h_1 - h_2) \times 0.163 = \text{gallons per cased well volume}$$

where

d = inside diameter of well casing

$h_1$  = depth of well from top of casing

$h_2$  = depth to water from top of casing.

4.3.5 The depth to the bottom of the well should be sounded and then compared to the completion form or diagram for the well. If sand or sediment are present inside the well, it

should first be removed by bailing. Do not insert bailers, pumps, or surge blocks into the well if obstructions, parting of the casing, or other damage to the well is suspected. Instead report the conditions to the Site Superintendent and obtain approval to continue or cease well development activities.

4.3.6 Begin development by first gently surging followed by bailing or pumping. This is then continued with alternate surging and bailing or pumping. At no time should the surge block be forced down the well if excessive resistance is encountered. During development, the bailer should not be allowed to free-fall or descend rapidly such that it becomes lodged in the casing or damages the end cap or sediment trap at the bottom of the well.

4.3.7 While developing, take periodic water level measurements (at least one every five minutes) to determine if drawdown is occurring and record the measurements on the Well Development Record (Attachment 1).

4.3.8 While developing, calculate the rate at which water is being removed from the well. Record the volume on the Well Development Record.

4.3.9 While developing, water is also periodically collected directly from the eductor pipe or bailer discharge and readings taken of the indicator parameters: pH, specific conductance, and temperature. Development is considered complete when the indicator parameters have stabilized (i.e., three consecutive pH, specific conductance, and temperature readings are within tolerances specified in the project work plans) and a minimum of three well volumes of water have been removed. In certain instances, for slow recharging wells, the parameters may not stabilize. In this case, well development is considered complete upon removal of the minimum of three well volumes. In some cases, the project work plans may also specify a maximum turbidity requirement for completion of development.

4.3.10 Obtain a water level and turbidity measurement at the completion of development.

4.3.11 Complete documentation of the well development event on the Well Development Record form. At a minimum this record must contain:

- Project name and number
- Well identification number
- Well depth, casing size, and completion date
- Method of development
- Volume of water removed
- Water levels (including the time of measurement)
- Physical description of the water (e.g., discoloration, turbidity, odor, etc.) and solids removed from the well
- Test equipment readings for pH, conductivity, temperature and turbidity (including the time of collection)
- Signature of the well development observer.

4.3.12 Collect and appropriately transport and dispose of water removed from the well in accordance with criteria listed in the project-specific work plans and regulatory requirements.

4.3.13 Allow the well to recover for at least 24 hours prior to sampling.

## **5.0 Records**

Records generated as a result of implementing this SOP will be controlled and maintained in the project record files in accordance with SQP 4.2.

## **6.0 Attachments**

6.1 Well Development Record form

SOP NO. 8.2

ATTACHMENT 6.1 –WELL DEVELOPMENT  
RECORD

PILOT-SCALE TREATIBILITY WORK PLAN

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## GROUNDWATER SAMPLING

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### STANDARD OPERATING PROCEDURE

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#### **1.0 Purpose**

This Standard Operating Procedure (SOP) establishes guidelines and procedures for use by field personnel in the collection and documentation of groundwater samples for chemical analysis. Proper collection procedures are necessary to assure the quality and integrity of all groundwater samples. Additional specific procedures and requirements will be provided in the project work plans, as necessary.

#### **2.0 References**

2.1 EPA, September 1987, Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.3 ASTM, 1988, Standards Technology Training Program - Groundwater and Vadose Zone Monitoring, Nielsen, et al.

2.4 SOP 1.1 - Chain of Custody

2.5 SOP 2.1 - Sample Handling, Packaging, and Shipping

2.6 SOP 5.1 - Water Level Measurements in Monitoring Wells

2.7 SOP 6.1 - Sampling Equipment and Well Material Decontamination

2.8 SOP 17.1 - Sample Labeling

2.9 SOP 17.2 - Sample Numbering

2.10 SOP 19.1 - On-Site Sample Storage

2.11 SOP 20.1 - Sample Collection, Preservation, and Holding Times

2.12 SQP 4.2 - Records Management

### **3.0 Definitions**

#### **3.1 Bladder Pump**

A bladder pump is an enclosed cylindrical tube containing a flexible membrane bladder. Well water enters the bladder through a one-way check-valve at the bottom. Gas is forced into the annular space (positive displacement) surrounding the bladder through a gas supply line. The gas displaces the well water through a one-way check-valve at the top. The water is brought to the surface through a water discharge line. Gas (air or nitrogen) is provided by compressors or cylinders.

#### **3.2 Peristaltic Pump**

A peristaltic pump is a self-priming, low volume pump consisting of a rotor and ball bearing rollers. Tubing placed around the rotors is squeezed by the rotors as they revolve. The squeezing produces a wavelike contractual movement which causes water to be drawn through the tubing. The peristaltic pump is limited to sampling at depths of less than 25 feet.

#### **3.3 Electric Submersible Pump**

An electric submersible pump is an enclosed cylindrical tube containing a motor with rotary attachments. Well water enters the cylinder through a one-way check valve. Electrical power to the motor causes rotors or impellers to turn and displace the groundwater.

#### **3.4 Bailer**

A bailer is an enclosed cylindrical tube containing a floating ball check-valve at the bottom. Lowering the bailer into water causes the ball to float allowing water to enter the cylinder. Raising the bailer through the water causes the ball to settle, creating a seal to trap the water so that it can be brought to the surface.

### **3.5 Dedicated Groundwater Monitoring Equipment**

Dedicated groundwater monitoring equipment is used to purge and sample only one well. The equipment is installed and remains in the well for the duration of the monitoring program.

Dedicated equipment does not need to be decontaminated between sampling events.

## **4.0 Procedure**

This section contains both the responsibilities and procedures involved with groundwater sampling. Proper groundwater sampling procedures are necessary to insure the quality and integrity of the samples. The details within this SOP should be used in conjunction with project work plans. The project work plans will generally provide the following information:

- Sample collection objectives
- Locations of groundwater samples to be collected
- Numbers and volumes of samples to be collected
- Types of chemical analyses to be conducted for the samples
- Specific quality control (QC) procedures and sampling required
- Any additional groundwater sampling requirements or procedures beyond those covered in this SOP, as necessary.

At a minimum, the procedures outlined in this SOP for groundwater sampling will be followed.

### **4.1 Responsibilities**

4.1.1 The Delivery Order Manager is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QC/QC).

4.1.2 The Contractor Quality Control Manager (CQCM) is responsible for periodic review of field generated documentation associated with this SOP. The CQCM is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans

and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

4.1.3 Field personnel assigned to surface and shallow subsurface soil sampling activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Site Superintendent, Delivery Order Manager, or the CQCM.

## **4.2 Groundwater Sampling Requirements**

### **4.2.1 Equipment Selection and Sampling Considerations**

Purging and sampling equipment is constructed from a variety of materials. The most inert material (e.g., Teflon, stainless steel), with respect to known or anticipated contaminants in the well(s), should be used whenever possible. The project work plans will describe the type of equipment to be used.

If non-dedicated sampling is to be used and the contaminant histories of the wells are known, it is advisable to establish a sampling order starting with the least contaminated well and progressing to the most contaminated last.

### **4.2.2 Groundwater Purging and Sampling with a Bladder Pump**

Pre-sample purging and sampling should be conducted in accordance with the project work plans. The standard procedure for purging and sampling using a bladder pump will be conducted as described below.

4.2.2.1 Inspect the equipment to ensure that it is in good working order.

4.2.2.2 Calibrate all field analytical test equipment (e.g., pH, temperature, conductivity) according to the instrument manufacturer's specifications. Calibration results will be recorded on the appropriate form(s) as specified by the project work plans. Instruments that cannot be calibrated according to the manufacturer's specifications will be removed from service and tagged.



An exception to the daily calibration requirements will be made in the case of the water level meters. These instruments will be calibrated at the beginning of the project and then every six months using a steel surveyors tape.

4.2.2.3 If non-dedicated equipment is being used, decontaminate according to SOP 6.1. During decontamination, the equipment should again be inspected for damage and, if present, repaired or replaced with undamaged equipment.

4.2.2.4 Visually inspect the well to ensure that it is undamaged, properly labelled and secured. Damage or other conditions that may affect the integrity of the well will be recorded on the Field Activity Daily Log (Attachment 6.1) and brought to the attention of the Site Superintendent.

4.2.2.5 Uncap the well and monitor the air space immediately above the open casing per the health and safety plan. Observe if any air is flowing into or out of the casing. In the event such conditions are observed, they should be noted on the Sampling Information Form (Attachment 6.2).

4.2.2.6 Obtain a depth to water level measurement according to the procedures outlined in SOP 5.1. Calculate the volume of water in the well (cased well volume) as follows:

$$\pi \times \left(\frac{d}{2}\right)^2 \times (h_1 - h_2) \times 7.48 = \text{cased well volume (in gallons)}$$

where

d = inside diameter of well casing (in feet)

$h_1$  = depth of well from top of casing (in feet)

$h_2$  = depth to water from top of casing (in feet)

Record static water level measurement and calculations on the Sampling Information Form (Attachment 6.2).

4.2.2.7 If using non-dedicated equipment, lower the pump and associated tubing and/or lines into the well.

4.2.2.8 Attach the compressor or cylinder to the controller and the controller to the gas supply line, making sure that the compressor is downwind of the monitoring well. Attach the sampling tube to the discharge supply line. Adjust the pressure/discharge cycle on the controller.

4.2.2.9 Begin purging. Collect, transport, and dispose of purge water in accordance with the criteria specified by the project work plans.

4.2.2.10 Physical parameters (pH, specific conductance, and temperature) of the purge water will be measured when purging begins and then periodically throughout the purging procedure. These measurements will be recorded on Sampling Information Form (Attachment 6.2). Purging is considered complete when a minimum of three casing volumes have been removed and pH, specific conductivity, and temperature measurements have stabilized (i.e., three consecutive pH, specific conductance, and temperature readings are within tolerances specified in the project work plans). If stability is not reached within the removal of three well volumes then purging is continued until a maximum of five cased well volumes have been removed.

For slowly recharging wells, the parameters may not stabilize. In this case, purging will be considered complete upon removal of a minimum three well volumes.

4.2.2.11 Allow the well to recover to at least 80 percent of the initial cased well volume prior to sampling.

4.2.2.12 Inspect the sampling bottles (obtained from the analytical laboratory prior to the sampling event) to be used to ensure that they are appropriate for the samples being collected, are undamaged, and have had the appropriate types and volumes of preservatives added. The types of sample containers to be used and sample preservation requirements will be provided in the project work plans and will comply with SOP 20.1.

4.2.2.13 Turn on the pump and adjust the pressure/discharge cycle on the pump controller so that the water will flow smoothly and without agitation into the sample containers.

4.2.2.14 Collect the sample directly into the provided sample bottle (container), allowing the discharge to flow gently down the inside of the bottle, minimizing aeration of the sample.

Completely fill the bottle; however, samples collected for metals and general water chemistry analysis should be filled to the base of the bottle neck.

4.2.2.15 The samples should be collected in the order of volatility, collecting the most volatile samples first, followed by the least volatile samples. The volatile samples should be collected during one full discharge cycle. Do not partially fill a volatile sample during one cycle and complete the filling during the next cycle.

4.2.2.16 Samples that require filtering should be collected last. The samples should preferably be filtered using a disposable vacuum filterization unit. The required filter mesh should be stipulated in the project work plans.

4.2.2.17 Cap the bottle and attach custody tape across the cap so that any attempt to remove the sample or open the sample bottle will be evident. Fill out and attach the sample label to the bottle per SOP 17.1. The sample will be assigned a sample number per SOP 17.2.

4.2.2.18 Document the sampling event on the Sample Collection Log (Attachment 6.3).

4.2.2.19 As soon as possible after sample collection, place the sample in a separate, appropriately sized, airtight, seam sealing, polyethylene bag (i.e., ziplock). Seal the bag, removing any excess air. Place the bagged sample inside the shipping container.

4.2.2.20 Handle and ship the sample according to the procedures outlined in SOP 2.1, following appropriate custody procedures described in SOP 1.1. Samples stored temporarily on site will be maintained per SOP 19.1.

#### **4.2.3 Groundwater Purging and Sampling with a Peristaltic Pump**

Purging and sampling will be conducted per the project work plans. The standard procedure for groundwater purging and sampling using a peristaltic pump will be conducted as described below.

4.2.3.1 Inspect the equipment to ensure that it is in good working order.

4.2.3.2 Conduct all field analytical test equipment (pH, temperature, conductivity) calibration as discussed in Section 4.2.2.2.

4.2.3.3 Conduct equipment decontamination as described in Section 4.2.2.3. However, the old Tygon™ tubing should not be decontaminated. New tubing should be used for each well.

4.2.3.4 Conduct wellhead inspection and air space monitoring as discussed in Sections 4.2.2.4 and 4.2.2.5.

4.2.3.5 Obtain a water level measurement and calculate the cased well volume per Section 4.2.2.6.

4.2.3.6 Connect new Tygon™ tubing to the rotor head of the pump motor and tighten until snug.

4.2.3.7 Run a short section of the tubing from the discharge side of the pump head to a collection vessel.

4.2.3.8 Insert the free end of the influent tubing into the well and lower it to the middle of the well screen.

4.2.3.9 Begin and conduct purging as described in Sections 4.2.2.9 and 4.2.2.10.

4.2.3.10 Purging will be considered complete per Section 4.2.2.10. Once purging is completed, allow the well to recover to at least 80 percent of the initial cased well volume prior to sampling.

4.2.3.11 Inspect the sampling bottles to be used per Section 4.2.2.12.

4.2.3.12 Turn on and adjust the rotor speed of the pump so that the water will flow smoothly and without agitation into the sample bottles.

4.2.3.13 Collect the sample directly into the provided sample bottle (container), allowing the discharge to flow gently down the inside of the bottle, minimizing aeration of the sample.

Completely fill the bottle; however, samples collected for metals and general water chemistry analyses should be filled to the base of the bottle neck.

4.2.3.14 The samples should be collected in the order of volatility as described in Section 4.2.2.15.

4.2.3.15 Samples that require filtering should be collected last. The samples should preferably be filtered using a disposable vacuum filterization unit. The required filter mesh should be stipulated in the project work plans.

4.2.3.16 Appropriately cap, label, and number the samples as discussed in Section 4.2.2.17.

4.2.3.17 Document the sampling event on the Sample Collection Log (Attachment 6.3).

4.2.3.18 Appropriately seal, store, handle, and ship the samples per Sections 4.2.2.19 and 4.2.2.20.

#### ***4.2.4 Groundwater Purging and Sampling with an Electric Submersible Pump***

Purging and sampling will be conducted in accordance with the project work plans. The standard procedure for purging and sampling using a submersible pump is described below.

4.2.4.1 Inspect the equipment to ensure that it is in good working order.

4.2.4.2 Conduct field analytical test equipment (pH, temperature, conductivity) calibration as discussed in Section 4.2.2.2.

4.2.4.3 Conduct equipment decontamination as described in Section 4.2.2.3.

4.2.4.4 Conduct wellhead inspection and air space monitoring as discussed in Sections 4.2.2.4 and 4.2.2.5.

4.2.4.5 Obtain a water level measurement and calculate the cased well volume per Section 4.2.2.6.

4.2.4.6 If using non-dedicated equipment, lower the pump and associated lines into the well.

4.2.4.7 Place the generator downwind of the well. Start the generator, and then plug the pump into the generator.

4.2.4.8 Begin and conduct purging as described in Sections 4.2.2.9 and 4.2.2.10.

4.2.4.9 Purging will be considered complete per Section 4.2.2.10. Once purging is completed, allow the well to recover to at least 80% of the initial cased well volume prior to sampling.

4.2.4.10 Inspect the sampling bottles to be used per Section 4.2.2.12.

4.2.4.11 Turn on and adjust the flow rate of the pump by using the check-valve on the discharge line so that the water will flow smoothly and without agitation into the sample bottles.

4.2.4.12 Collect the sample directly into the provided sample bottle (container), allowing the discharge to flow gently down the inside of the bottle, minimizing aeration of the sample. Completely fill the bottle; however, samples collected for metals and general water chemistry analyses should be filled to the base of the bottle neck.

4.2.4.13 The samples should be collected in the order of volatility, as described in Section 4.2.2.15. An electric submersible pump is not recommended for collecting volatile organic samples.

4.2.4.14 Samples that require filtering should be collected last. The samples should preferably be filtered using a disposable vacuum filterization unit. The required filter mesh should be stipulated in the project work plans.

4.2.4.15 Appropriately cap, label, and number the samples as discussed in Section 4.2.2.17.

4.2.4.16 Document the sampling event on the Sample Collection Log (Attachment 6.3).

4.2.4.17 Appropriately seal, store, handle and ship the samples per Sections 4.2.2.19 and 4.2.2.20.

#### **4.2.5 Groundwater Purging and Sampling with a Bailer**

Purging and sampling will be conducted in accordance with the project work plans. The standard procedure for purging and sampling with a bailer is described below.

4.2.5.1 Inspect the equipment to ensure that it is in good working order.

4.2.5.2 Conduct field analytical test equipment (pH, temperature, conductivity) calibration as discussed in Section 4.2.2.2.

4.2.5.3 Decontaminate purging and sampling equipment according to SOP 6.1.

4.2.5.4 Conduct wellhead inspection and air space monitoring as discussed in Sections 4.2.2.4 and 4.2.2.5.

4.2.5.5 Obtain a water level measurement and calculate the cased well volume per Section 4.2.2.6.

4.2.5.6 Secure the bailer to a five foot length of Teflon™ coated stainless bailer wire with a bowline knot or clip. Attach the bailer wire to bailing line or chain.

4.2.5.7 Begin purging by slowly lowering the bailer into the groundwater. Allow the floating ball valve to seat, and slowly retrieve the bailer. Repeat this procedure to purge the well. Collect, transport, and dispose of purge water in accordance with the criteria specified in the project work plans.

During purging, the descent of the bailer should be controlled to prevent freefall inside the well. In the event the bailer encounters an obstruction inside the well, no attempts may be made to push the bailer beyond the obstruction. If the bailer becomes lodged in the well, the line should not be pulled with such force that it would part from the bailer. Such conditions should also be

noted in the Field Activity Daily Log and brought to the immediate attention of the Site Superintendent.

4.2.5.8 Purging will be considered complete per Section 4.2.2.10. Once purging is completed, allow the well to recover to at least 80% of the initial cased well volume prior to sampling.

4.2.5.9 Inspect the sampling bottles to be used per Section 4.2.2.12.

4.2.5.10 Lower the sample collection bailer and submerge into the water column as above. Retrieve the bailer and insert a bottom emptying device into the bailer so that the water will flow smoothly and without agitation into the sample bottles.

4.2.5.11 Collect the sample water directly into the provided sample bottles (containers), allowing the discharge to flow gently down the inside of the bottles, minimizing aeration of the sample. Completely fill the bottles; however, samples collected for metals and general water chemistry analyses should be filled to the base of the bottle neck.

4.2.5.12 The samples should be collected in the order of volatility as described in Section 4.2.2.15.

4.2.5.13 Samples that require filtering should be collected last. The samples should preferably be filtered using a disposable vacuum filterization unit. The required filter mesh should be stipulated in the project work plans.

4.2.5.14 Appropriately cap, label, and number the samples as discussed in Section 4.2.2.17.

4.2.5.15 Document the sampling event on the Sample Collection Log (Attachment 6.3).

4.2.5.16 Appropriately seal, store, handle, and ship the samples per Sections 4.2.2.19 and 4.2.2.20.

## **5.0 Records**

5.1 Records generated as a result of this SOP will be controlled and maintained in the project record files in accordance with SQP 4.2.



## **6.0 Attachments**

- 6.1 Field Activity Daily Log
- 6.2 Sampling Information Form
- 6.3 Sample Collection Log

SOP NO. 9.1

ATTACHMENT 6.1 – FIELD ACTIVITY DAILY LOG

PILOT-SCALE TREATIBILITY WORK PLAN

THE ABOVE IDENTIFIED ATTACHMENT IS NOT  
AVAILABLE.

EXTENSIVE RESEARCH WAS PERFORMED BY  
NAVFAC SOUTHWEST TO LOCATE THIS  
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AS A PLACEHOLDER AND WILL BE REPLACED  
SHOULD THE MISSING ITEM BE LOCATED.

QUESTIONS MAY BE DIRECTED TO:

**DIANE C. SILVA**  
**RECORDS MANAGEMENT SPECIALIST**  
**NAVAL FACILITIES ENGINEERING COMMAND**  
**SOUTHWEST**  
**1220 PACIFIC HIGHWAY**  
**SAN DIEGO, CA 92132**

**TELEPHONE: (619) 532-3676**

SOP NO. 9.1

ATTACHMENT 6.2 – SAMPLING INFORMATION  
FORM

PILOT-SCALE TREATIBILITY WORK PLAN

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**SOUTHWEST**  
**1220 PACIFIC HIGHWAY**  
**SAN DIEGO, CA 92132**

**TELEPHONE: (619) 532-3676**

SOP NO. 9.1

ATTACHMENT 6.3 – SAMPLE COLLECTION LOG

PILOT-SCALE TREATABILITY WORK PLAN

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**TELEPHONE: (619) 532-3676**

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## **CONE PENETRATION TESTING (CPT) AND HYDROPUNCH® GROUNDWATER SAMPLING**

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### **STANDARD OPERATING PROCEDURE**

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#### ***1:0 Purpose***

This Standard Operating Procedure (SOP) establishes guidelines for conducting cone penetration testing (CPT), soil sampling using a CPT rig, and Hydropunch® groundwater sampling. The details within this SOP should also be used in conjunction with project work plans.

#### ***2.0 References***

2.1 ASTM, 1988, Standard Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil, Designation: D 3441-86, Volume 4.08 Soil and Rock, Building Stones: Geotextiles, pp.409-414.

2.2 Manchon, B., 1992, Introduction to Cone Penetrometer Testing and Groundwater Samplers, Sixth National Outdoor Action Conference on Aquifer Restoration, Groundwater Monitoring and Geophysical Methods, May 1992.

2.3 SOP 1.1 - Chain of Custody

2.4 SOP 2.1 - Sample Handling, Packaging, and Shipping

2.5 SOP 6.1 - Sampling Equipment and Well Material Decontamination

2.6 SOP 6.2 - Drilling and Heavy Equipment Decontamination

2.7 SQP 4.2 - Records Management

#### ***3.0 Definitions***

3.1 Cone - the cone-shaped point of the penetrometer tip, upon which the end-bearing resistance develops.

3.2 Cone penetrometer - an instrument in the form of a cylindrical rod with a conical point, designed for penetrating soil and soft rock and for measuring the end-bearing component of penetration resistance.

3.3 Cone resistance or end-bearing resistance - the resistance to penetration developed by the cone, equal to the vertical force applied to the cone divided by its horizontally projected area.

3.4 Hydropunch<sup>®</sup> - A device used to collect groundwater samples using CPT or drill rig technology. Various forms of the Hydropunch<sup>®</sup> exist; they vary in the method used for sample collection. Hydropunch I<sup>®</sup> uses the body of the hydropunch to collect and retrieve the sample. Hydropunch II<sup>®</sup> allows for the collection of water samples using a bailer lowered within the CPT rods or drill stem.

3.5 Sounding - the entire series of penetration tests performed at one location.

3.6 Friction Ratio - the ratio of friction resistance to cone resistance, expressed in percent.

3.7 Friction Resistance - the resistance to penetration developed by the friction sleeve, equal to the vertical force applied to the sleeve divided by its surface area. This resistance consists of the sum of friction and adhesion.

3.8 Differential Pore Pressure Ratio - A calculated parameter equal to the excess pore pressure measured behind the tip divided by the sum of the tip resistance (corrected for pore pressure effects and the total overburden stress). Used in combination with the end-bearing resistance to infer lithology.

3.9 Pore Pressure - Water pressure in the formation.

3.10 Push Rods - The thick-walled tubes, or other suitable rods, used for advancing the penetrometer tip or Hydropunch<sup>®</sup> to the required test depth.

## **4.0 Procedure**

Depending on the sampling activities to be performed, CPT/Hydropunch® testing may require multiple runs to complete the desired tests. The first run is generally conducted to generate stratigraphic or hydrogeologic information. The stratigraphic or hydrogeologic data is then evaluated to determine optimum depth intervals to obtain soil and groundwater samples, which will be collected in subsequent runs.

CPT soundings, and soil and groundwater sampling will be performed by an experienced contractor under the direction of the prime contractor or their subcontractors. All CPT, soil sampling, and Hydropunch® techniques covered in this SOP will be performed in accordance with the project work plans. The project work plans will identify the following:

- Testing and sampling objectives
- Locations and depths of CPT and sampling points
- Numbers and volumes of soil or groundwater samples to be collected
- Types of chemical analyses to be conducted for the samples
- Specific quality control (QC) procedures and sampling required
- Specific procedures to be performed in addition to those covered in this SOP.

At a minimum, the procedures outlined below for CPT, soil sampling, and Hydropunch® groundwater sampling will be followed.

### **4.1 Responsibilities**

4.1.1 The Project Manager or delegated representative is responsible for ensuring that all CPT, soil sampling, and Hydropunch® activities are conducted and documented in accordance with this and any other appropriate procedures. This will be accomplished by staff training and by maintaining quality assurance/quality control (QA/QC).

4.1.2 The Contractor Quality Control Manager (CQCM) is responsible for periodic review of field activities and documentation associated with this SOP. The CQCM is also responsible for the implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, generation of variances to CPT and sampling requirements, issuing nonconformances, etc.) if problems occur.

4.1.3 Field personnel assigned to CPT, soil sampling, and Hydropunch® activities are responsible for completing their tasks according to this and other appropriate procedures. All staff are responsible for reporting deviations from the procedure to the Site Superintendent, Delivery Order Manager, or the CQCM.

#### **4.2 Preparation Procedures**

4.2.1 Prior to commencement of CPT activities, ensure that all CPT, soil sampling, and Hydropunch® locations have been appropriately cleared of all underground utilities and buried objects per the project work plans. Review all forms and diagrams documenting the location of the cleared sampling and CPT locations, as well as that of any underground utility lines or other buried objects.

4.2.2 Perform a specific calibration of air monitoring equipment required for air space monitoring according to the instrument manufacturer's specifications. Calibration results will be recorded on the appropriate form(s), as specified in the project work plans. Instruments that can not be calibrated according to the manufacturer's specifications will be removed from service and tagged.

4.2.3 Don the appropriate personal protection equipment specified in the project-specific work plans.

#### **4.3 Cone Penetration Testing**

In general, the CPT is the first run to be conducted. The CPT rig is normally truck-mounted and contains a hydraulic push system (20 ton is typical). The depth of investigation will typically be less than 100 feet below ground surface (bgs). Lighter weight rigs can be utilized for shallow surveys up to approximately 15 feet bgs.

Some CPT rigs are equipped with an automatic decontamination system featuring an enclosed chamber that may be mounted beneath the CPT rig (project-specific decontamination requirements are specified in the project work plans). This chamber contains scrubbers and spray nozzles for pressure washing of the CPT probe as it is retrieved from the ground. In this type of system, all activities are conducted within the enclosed CPT rig.



The standard procedure for conducting stratigraphic and hydrogeologic investigations is described below.

4.3.1 Obtain specifications on the type and dimensions of the probes and equipment, along with the results of current shop calibrations from the CPT subcontractor.

4.3.2 With the CPT subcontractor, inspect all equipment to ensure that it is in proper working order.

4.3.3 Examine data from adjacent soil borings, if available. Initial correlation of the CPT data with site lithologies will be accomplished by comparison with existing boring logs, geophysical logs, and CPT logs.

4.3.4 Before moving onto the site, decontaminate the outside of the rig per SOP 6.2 and the project work plans. For those rigs that do not have an automatic decontamination system, the CPT probe and rods should also be decontaminated per SOP 6.2.

4.3.5 Calibrate the CPT cones at zero load reading in air and water, shielding the cone from direct sunlight before commencement of testing at each location.

4.3.6 Commence the test and advance the CPT probe into the subsurface at a consistent, controlled rate of 0.03 to 0.07 feet per second (1 to 2 centimeter per second), unless conditions prevent that rate.

4.3.7 Record real-time field plots consisting of depth, cone tip resistance, sleeve friction resistance, and friction ratio. Pore pressure and differential pore pressure ratio may be included in some cases.

4.3.8 Pore pressure dissipation tests may be conducted to determine relative flow rates at specific depths. The CPT probe is held stationary at a given depth and data are recorded for a set time interval. The time interval is dependent on the lithology of the zone being tested.

4.3.9 Once the CPT is pushed to the maximum desired depth, data collection is terminated. The CPT is retracted from the hole and the tip and rods are wiped down during extraction.

4.3.10 Upon completion of a test, calibrate the piezocone again to zero load reading and compare this to the initial reading.

4.3.11 Abandon the hole in accordance with the project work plans.

4.3.12 All pertinent information observed during the investigations will be recorded by the rig geologist or engineer. Information will be recorded on the Field Activity Daily Log (FADL) (Attachment 6.1) and/or appropriate form(s) as specified in the project work plans. Any and all problems or unusual conditions encountered should also be noted on the above forms and brought to the attention of the site superintendent.

#### **4.4 Soil Samples**

If required, soil sampling will follow the CPT analysis run. Soil sampling locations will be placed updip relative to the location of the previous CPT testing run. The standard procedure is described below.

4.4.1 Assemble and check the necessary sampling equipment before soil sampling. Decontaminate all downhole sampling equipment before sampling, as described in SOP 6.1. The rig should also be decontaminated per SOP 6.2.

4.4.2 Deploy and advance the soil sampling probes with the CPT rods to collect soil samples at the sample intervals specified in the project work plans. The sample intervals may be identified from the adjacent CPT data and any other subsurface data available. The sampling device contains removable liners that fit inside the drive tip mechanism.

4.4.3 Retrieve the sampler and remove the liners containing the soil. Cover the ends of each liner to be submitted for chemical analysis with Teflon™ film and then cap with plastic end caps.

4.4.4 Each liner to be submitted for analysis will be appropriately labeled. The label will be filled out using waterproof ink and will contain, at a minimum, the following information:

- Project number
- Sample point (or boring) number
- Bottom depth of liner
- Date and time of sample collection
- Parameters for analysis
- Sampler's initials.

4.4.5 As soon as possible after sample collection, place the sample in an appropriately sized, airtight, seam-sealing polyethylene bag (e.g., ziplock). Seal the bag, removing any excess air, and tape the bag with custody tape so that any attempt to remove the sample will cause the tape to be broken.

4.4.6 Document the sampling event on the Sample Collection Log (Attachment 6.1) or an equivalent form as specified in the project work plans.

4.4.7 Handle the sample according to the procedures outlined in SOP 2.1. For samples submitted to a laboratory for analysis, an Analysis Request and Chain-of-Custody Record (Attachment 6.3) shall be completed and maintained per SOP 1.1 and the project work plans.

4.4.8 Abandon the hole following the procedure outlined in the project work plans.

#### **4.5 *Hydropunch® Groundwater Samples***

The Hydropunch® sample locations, if conducted in conjunction with CPT data collection, will be located a few feet in the estimated upgradient direction from the previous CPT location. Hydropunch® sampling will be conducted in accordance with the project work plans. The standard procedure for Hydropunch® sampling is described below.

4.5.1 Decontaminate the Hydropunch® probe and push/drive rods in accordance with SOP 6.1. If the Hydropunch® model is being used with a small diameter bailer, the bailer and associated equipment must also be decontaminated in accordance with SOP 6.1.

4.5.2 Advance the probe to the target depth, which will commonly be a permeable layer as defined from the adjacent CPT or other stratigraphic information. Depth control is maintained by counting the number of whole and partial push or drive rods used. The Hydropunch® is measured at the tip of the tool and zeroed at the ground surface.

4.5.3 To obtain a groundwater sample, retract the outer jacket of the Hydropunch® probe to allow groundwater inflow into the sample chamber. An optional technique, used to determine when the sample chamber is full as follows:

- Place a surgical glove over the end of the push rod before the outer jacket of the sampler is retracted.
- As water enters the sample chamber and displaces air, the glove will inflate.
- Once the glove stops inflating, water has ceased flowing into the chamber and the sample may be retrieved.

The length of time required for the sample chamber to fill is a function of the relative permeability of the formation and the presence or absence of materials which may clog the filter screen, thereby inhibiting the flow of water.

4.5.4 Retract the probe from the hole, disconnect the push rods from the Hydropunch®, and remove the upper valve. Replace the upper valve with a Teflon™ stop cock valve and a disposable tube (Hydropunch® I). Turn the sampler upside down, open the cock valve and decant the sample into the sample container.

4.5.5 If using the Hydropunch® II model with a small diameter bailer, the water sample is retrieved by lowering the bailer through the inside of the push rod into the sample chamber. The water recovered in the bailer is then decanted directly into the appropriate sample containers.

4.5.6 If collecting samples for analysis of volatile organic compounds (VOCs), first completely fill the VOC sample vials. Each filled, capped vial will be inverted to ensure no air bubbles are present. If an air bubble is present, the vial will be opened and refilled with an additional sample. The vial will be immediately capped and checked again for bubbles. If

air bubbles are still present, the VOC sample vial will be discarded and a new vial used. The VOC sample vial filling procedure is then repeated until no air bubbles are present.

4.5.7 If other sample analyses are required, fill the other sample containers after the VOC sample vials are filled. Samples collected for metals and general minerals analysis will be filled to the base of the bottle neck. Care will be taken not to aerate the sample during transfer from the bailer to the sample bottles and not to overfill bottles containing preservatives. All samples shall be appropriately preserved per SOP 9.1 and the project work plans.

4.5.8 Each sample container to be submitted for analysis will be appropriately labeled. The label will be filled out using waterproof ink and will contain, at a minimum, the following information:

- date and time sample was collected
- sample location
- the initials of the individual conducting the sampling
- any additional required information.

4.5.9 Document the sampling event on the Sample Collection Log (Attachment 6.2) or an equivalent form as specified in the project work plans.

4.5.10 Place the labeled vials in seam-sealing plastic bags (i.e., ziplock). Seal the bag, removing any excess air, and tape the bag with custody tape so that removal of the sample will cause the tape to be broken.

4.5.11 Conduct a visual inspection of the turbidity of samples and record on the FADL (Attachment 6.1) and on the Sample Collection Log (Attachment 6.2) to provide a qualitative record of results.

4.5.12 Handle the samples according to procedures outlined in SOP 2.1. For samples submitted to a laboratory for analysis, an Analysis Request and Chain-of-Custody Record (Attachment 6.3) shall be completed and maintained per SOP 1.1 and the project work plans.

4.5.13 After samples are collected, water levels may be measured. For water level measurements using the Hydropunch<sup>®</sup>, allow enough time for groundwater to fill the sample chamber and the push rods. After static water level conditions are achieved, an electric tape is lowered through the push rods and the water level is measured. Document results on the appropriate form, as specified by the project-specific work plans.

4.5.14 Abandon the hole following the procedure outlined in the project work plans.

#### **4.6 Reporting**

The CPT contractor should provide a field survey report of the test data before demobilizing from each location. The CPT contractor should record on the survey report the operator's name, date of the survey, and the CPT location number. The report should include the following:

- descriptions of the various probes and equipment, and the results of calibrations performed;
- profiles of cone tip resistance, sleeve friction resistance, friction ratio, inclination, pore pressures, and differential pore pressure ratio versus depth; and
- a list of the derived geotechnical parameters related to the subsurface conditions, including soil types, standard penetration test blow counts, relative density, and shear strengths.

The report should then be reviewed, approved, and signed by the rig geologist, rig engineer, or other responsible individual as identified in the project work plans. The report should be maintained per Section 5.0.

#### **5.0 Records**

Records generated as a result of implementation of this SOP will be controlled and maintained in the project record files in accordance with SQP 4.2.

#### **6.0 Attachments**

6.1 Field Activity Daily Log

6.2 Sample Collection Log

### 6.3 Analysis Request and Chain-of-Custody Record

Berkeley  
Environmental  
Restoration  
Center

Daily Log	DATE			
	NO			
	SHEET	OF		

## FIELD ACTIVITY DAILY LOG

PROJECT NAME		PROJECT NO.	
PROJECT ACTIVITY SUBJECT:			
DESCRIPTION OF DAILY ACTIVITIES AND EVENTS:			
VISITORS ON SITE:		CHANGE FROM PLANS AND SPECIFICATION, AND OTHER SPECIAL ORDERS AND IMPORTANT DECISIONS.	
WEATHER CONDITIONS:		IMPORT TELEPHONE CALLS:	
BERC PERSONNEL ON SITE			
SIGNATURE		DATE:	

FIGURE 6-3





COMMENTS: (Continued)		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%;">DATE</td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> <td style="width: 10%;"></td> </tr> <tr> <td>TIME</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>PAGE</td> <td colspan="5">_____ OF _____</td> </tr> <tr> <td>PAGE</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td colspan="6">PROJECT NO.</td> </tr> </table>	DATE						TIME						PAGE	_____ OF _____					PAGE						PROJECT NO.					
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PAGE	_____ OF _____																															
PAGE																																
PROJECT NO.																																

PREPARED BY: \_\_\_\_\_

#### LEGEND

1. A SAMPLE COLLECTION LOG IS TO BE COMPLETED FOR EACH SAMPLE.
2. ALWAYS COMPLETE BOTH SIDES. IF SECOND SIDE IS NOT USED, DRAW A LINE THROUGH IT AND MARK N/A. FILL IN CONTROL BLOCK AND PREPARED BY.
3. ALL ENTRIES ON LOG ARE TO BE COMPLETED. IF NOT APPLICABLE MARK N/A.
4. DATE: USE MONTH/DAY/YEAR: I.E., 10/30/85
5. TIME: USE 24-HOUR CLOCK: I.E., 1835 FOR 6:35 P.M.
6. PAGE: EACH SAMPLE TEAM SHOULD NUMBER PAGE \_\_\_\_\_ OF \_\_\_\_\_ FOR THE DAY'S ACTIVITIES FOR ALL SHEETS PREPARED ON A SINGLE DAY. I.E., IF THERE ARE A TOTAL OF 24 PAGES (INCLUDING FRONT AND BACK) NUMBER 1 OF 24, 2 OF 24, ETC.
7. SAMPLE LOCATION: USE BORING OR MONITORING WELL NUMBER, GRID LOCATION (TRANSECT), SAMPLING STATION I.D., OR COORDINATE TO PHYSICAL FEATURES WITH DISTANCES. INCLUDE SKETCH IN COMMENT SECTION IF NECESSARY.
8. SAMPLE TYPE: USE THE FOLLOWING - SOIL, WATER (SURFACE OR GROUND), AIR (FILTERS, TUBES, AMBIENT, PERSONNEL), SLUDGE, DRUM CONTENTS, OIL, VEGETATION, WIPE, SEDIMENT
9. COMPOSITE TYPE: I.E., 24-HOUR, LIST SAMPLE NUMBERS IN COMPOSITE, SPATIAL COMPOSITE.
10. DEPTH OF SAMPLE. GIVE UNITS. WRITE OUT UNITS SUCH AS INCHES, FEET. DON'T USE "OR"
11. WEATHER. APPROXIMATE TEMPERATURE, SUN AND MOISTURE CONDITIONS
12. CONTAINERS USED. LIST EACH CONTAINER TYPE AS NUMBER, VOLUME, MATERIAL (E.G., 2 - 1L GLASS, 4 - 40 ML GLASS VIAL, 1 - 400 ML PLASTIC, 1 - 3 INCH STEEL TUBE, 1 - 8 OZ. GLASS JAR)
13. AMOUNT COLLECTED. VOLUME IN CONTAINERS (E.G., 1/2 FULL)

**FIGURE 7-2 (CONT'D)**

# CHAIN OF CUSTODY / ANALYSES REQUEST FORM

Project No.:						Field Logbook No.:				Date:		Serial No.: 8829													
Project Name:						Project Location:																			
Sampler (Signature) :							ANALYSES											Samplers:							
SAMPLES							EPA 601	EPA 624							HOLD	RUSH	REMARKS								
SAMPLE NO.	DATE	TIME	LAB SAMPLE NO.	NO. OF CON-TAINERS	SAMPLE TYPE																				
RELINQUISHED BY: (Signature)						DATE	TIME	RECEIVED BY: (Signature)						DATE	TIME										
RELINQUISHED BY: (Signature)						DATE	TIME	RECEIVED BY: (Signature)						DATE	TIME										
RELINQUISHED BY: (Signature)						DATE	TIME	RECEIVED BY: (Signature)						DATE	TIME										
METHOD OF SHIPMENT:						DATE	TIME	LAB COMMENTS:																	
Sample Collector:										Analytical Laboratory:															

---

# **SAMPLE LABELING**

---

## **STANDARD OPERATING PROCEDURE**

---

### **1.0 Purpose**

This Standard Operating Procedure (SOP) establishes guidelines and procedures for sample labeling. Sample labeling is required to identify, track and trace samples from the time of collection until the time of disposal. Additional specific procedures and requirements will be provided in the project work plans.

### **2.0 References**

2.1 EPA, September 1987, Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.3 SQP 4.2 - Records Management

### **3.0 Definitions**

#### **3.1 Sample Label**

Sample labels include all forms of sample identification (labels or tags) that are physically attached to samples collected and provide, at a minimum, the information required by this SOP and project work plans. An example sample label is shown as Attachment 6.1

### **4.0 Procedure**

This section contains both the responsibilities and procedures involved with sample labeling. Sample labeling is required to identify, track and trace samples from the time of collection until the time of disposal. The details within this SOP should be used in conjunction with the project work plans. The project work plans will commonly provide the following information:

- Sample collection objectives
- Numbers, types and locations of samples to be collected
- Any additional sample labeling requirements or procedures beyond those covered in this SOP, as necessary.

#### **4.1 Responsibilities**

4.1.1 The Delivery Order Manager is responsible for ensuring that all sample collection and labeling activities are conducted and documented in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

4.1.2 The Contractor Quality Control Manager (CQCM) is responsible for periodic review of field generated documentation associated with this sample labeling SOP. The CQCM is also responsible for the implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to sample labeling requirements, issuing nonconformances, etc.) if problems occur.

4.1.3 Field personnel assigned to sampling and sample labeling activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from the procedures to the Site Superintendent, Delivery Order Manager, or the CQCM.

#### **4.2 Sample Labeling**

4.2.1 Document all the information necessary on the sample label and ensure that the label is physically attached to each respective sample. Each sample label must contain at a minimum the following information:

- Project name
- Project number
- Date and time of collection
- Sample location
- Sample identification number
- Collector's name
- Preservative used (if any).

Additional information may also be required per the project work plans and must accordingly be included on all sample labels.

4.2.2 Indelible ink should be used in filling out all sample labels.

4.2.3 Ensure that each sample collected has a sample label.

4.2.4 Ensure that the information documented on the sample label corresponds with the information documented on the Sample Collection Log (Attachment 6.2), Sampling Information Form for groundwater samples (Attachment 6.3) and Chain-of-Custody Record (Attachment 6.4).

## **5.0 Records**

5.1 Records generated as a result of implementation of this SOP will be controlled and maintained in the project record file in accordance with SQP 4.2.

## **6.0 Attachments**

6.1 Example Sample Label

6.2 Sample Collection Log

6.3 Sampling Information Form

6.4 Chain-of-Custody Record

SOP NO. 17.1

ATTACHMENT 6.1 – EXAMPLE SAMPLE LABEL

PILOT-SCALE TREATIBILITY WORK PLAN

THE ABOVE IDENTIFIED ATTACHMENT IS NOT  
AVAILABLE.

EXTENSIVE RESEARCH WAS PERFORMED BY  
NAVFAC SOUTHWEST TO LOCATE THIS  
ATTACHMENT. THIS PAGE HAS BEEN INSERTED  
AS A PLACEHOLDER AND WILL BE REPLACED  
SHOULD THE MISSING ITEM BE LOCATED.

QUESTIONS MAY BE DIRECTED TO:

**DIANE C. SILVA**  
**RECORDS MANAGEMENT SPECIALIST**  
**NAVAL FACILITIES ENGINEERING COMMAND**  
**SOUTHWEST**  
**1220 PACIFIC HIGHWAY**  
**SAN DIEGO, CA 92132**

**TELEPHONE: (619) 532-3676**

SOP NO. 17.1

ATTACHMENT 6.2 – SAMPLE COLLECTION LOG

PILOT-SCALE TREATIBILITY WORK PLAN

THE ABOVE IDENTIFIED ATTACHMENT IS NOT  
AVAILABLE.

EXTENSIVE RESEARCH WAS PERFORMED BY  
NAVFAC SOUTHWEST TO LOCATE THIS  
ATTACHMENT. THIS PAGE HAS BEEN INSERTED  
AS A PLACEHOLDER AND WILL BE REPLACED  
SHOULD THE MISSING ITEM BE LOCATED.

QUESTIONS MAY BE DIRECTED TO:

**DIANE C. SILVA**  
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**NAVAL FACILITIES ENGINEERING COMMAND**  
**SOUTHWEST**  
**1220 PACIFIC HIGHWAY**  
**SAN DIEGO, CA 92132**

**TELEPHONE: (619) 532-3676**



SOP NO. 17.1

ATTACHMENT 6.3 – SAMPLING INFORMATION  
FORM

PILOT-SCALE TREATIBILITY WORK PLAN

THE ABOVE IDENTIFIED ATTACHMENT IS NOT  
AVAILABLE.

EXTENSIVE RESEARCH WAS PERFORMED BY  
NAVFAC SOUTHWEST TO LOCATE THIS  
ATTACHMENT. THIS PAGE HAS BEEN INSERTED  
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**DIANE C. SILVA**  
**RECORDS MANAGEMENT SPECIALIST**  
**NAVAL FACILITIES ENGINEERING COMMAND**  
**SOUTHWEST**  
**1220 PACIFIC HIGHWAY**  
**SAN DIEGO, CA 92132**

**TELEPHONE: (619) 532-3676**

SOP NO. 17.1

ATTACHMENT 6.4 – CHAIN-OF-CUSTODY  
RECORD

PILOT-SCALE TREATIBILITY WORK PLAN

THE ABOVE IDENTIFIED ATTACHMENT IS NOT  
AVAILABLE.

EXTENSIVE RESEARCH WAS PERFORMED BY  
NAVFAC SOUTHWEST TO LOCATE THIS  
ATTACHMENT. THIS PAGE HAS BEEN INSERTED  
AS A PLACEHOLDER AND WILL BE REPLACED  
SHOULD THE MISSING ITEM BE LOCATED.

QUESTIONS MAY BE DIRECTED TO:

**DIANE C. SILVA**  
**RECORDS MANAGEMENT SPECIALIST**  
**NAVAL FACILITIES ENGINEERING COMMAND**  
**SOUTHWEST**  
**1220 PACIFIC HIGHWAY**  
**SAN DIEGO, CA 92132**

**TELEPHONE: (619) 532-3676**

---

## **SAMPLE NUMBERING**

---

### **STANDARD OPERATING PROCEDURE**

---

#### **1.0 Purpose**

This Standard Operating Procedure (SOP) establishes guidelines and procedures for sample numbering. Sample numbering is required to identify, track and trace samples from the time of collection until the time of disposal. Additional specific procedures and requirements will be provided in the project work plans.

#### **2.0 References**

2.1 EPA, September 1987, Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.3 SOP 17.1 - Sample Labeling

2.4 SQP 4.2 - Records Management

#### **3.0 Definitions**

##### **3.1 Sample Number**

A sample number is a unique alphanumeric identification assigned to each and all physical samples collected as part of any given project.

#### **4.0 Procedure**

This section contains both the responsibilities and procedures involved with sample numbering. Sample numbering is required to provide a means by which samples can be identified, tracked and traced from the time of collection until the time of disposal. The details within this SOP should be used in conjunction with project work plans. The project work plans will generally provide the following information:

- Sample collection objectives
- Numbers, types, and locations of samples to be collected
- Project-specific character string to be used for the sample numbering
- Person responsible for issuing sample numbers to field personnel conducting sampling activities
- Any additional sample numbering requirements or procedures beyond those covered in this SOP, as necessary.

#### ***4.1 Responsibilities***

4.1.1 The Delivery Order Manager is responsible for ensuring that all sample collection and numbering activities are conducted and documented in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

4.1.2 The Contractor Quality Control Manager (CQCM) is responsible for periodic review of field generated documentation associated with this SOP. The CQCM is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to sample numbering requirements, issuing nonconformances, etc.) if problems occur.

4.1.3 Field personnel assigned to sampling and sample numbering activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from the procedures to the Site Superintendent, Delivery Order Manager, or the CQCM.

#### ***4.2 Sample Numbering***

4.2.1 The alphanumeric character string (AANNNN vs. AAANNNNN) will be determined on a project-specific basis and stated in the project work plans. The sample numbers should be as simple and preferably as short as possible; however, they should also be compatible with the laboratory analytical tracking system and the data management system to be used for the project sample data.

4.2.2 A unique sample number will be assigned in the field to each sample to be submitted for analysis.

4.2.3 The sample numbers will be assigned sequentially (e.g. SB-1000, SB-1001) as the samples are collected. Both environmental (soil, sediment, groundwater, air, etc.) and QC samples will be assigned sequential sample numbers with the same prefix so that the laboratory will be unable to distinguish between the QC and non-QC samples.

4.2.4 The sample number will be recorded, using indelible ink, directly on the sample label attached to each sample per SOP 17.1. Prenumbered tape may also be used and affixed to each sample; however, their use is not mandatory for this SOP. When used, the sample number on the preprinted tape must also be recorded on the sample label.

4.2.5 The sample number must also be recorded on the Sample Collection Log (Attachment 6.1), Sampling Information Form for groundwater samples (Attachment 6.2), and Chain-of-Custody Record (Attachment 6.3).

4.2.6 It is recommended that one person (either the Site Superintendent or other designee) be responsible for issuing sample numbers to field sampling personnel and ensuring that the sample sequence numbers are applied to samples in the sequence in which they are collected.

4.2.7 It is also recommended the field supervisor or designee be responsible for keeping a master sample log listing the sample numbers and a brief description of the samples collected.

## **5.0 Records**

Records generated as a result of implementation of this SOP will be controlled and maintained in the project record files in accordance with SQP 4.2.

## **6.0 Attachments**

6.1 Sample Collection Log

6.2 Sampling Information Form

### 6.3 Chain of Custody Record



COMMENTS:  
(Continued)

DATE

TIME

PAGE \_\_\_\_ OF \_\_\_\_

PAGE

PROJECT NO.

PREPARED BY: \_\_\_\_\_

#### LEGEND

1. A SAMPLE COLLECTION LOG IS TO BE COMPLETED FOR EACH SAMPLE.
  2. ALWAYS COMPLETE BOTH SIDES. IF SECOND SIDE IS NOT USED, DRAW A LINE THROUGH IT AND MARK N/A. FILL IN CONTROL BLOCK AND PREPARED BY.
  3. ALL ENTRIES ON LOG ARE TO BE COMPLETED. IF NOT APPLICABLE MARK N/A.
  4. DATE: USE MONTH/DAY/YEAR: I.E., 10/30/85
  5. TIME: USE 24-HOUR CLOCK: I.E., 1835 FOR 6:35 P.M.
  6. PAGE: EACH SAMPLE TEAM SHOULD NUMBER PAGE \_\_\_\_ OF \_\_\_\_ FOR THE DAY'S ACTIVITIES FOR ALL SHEETS PREPARED ON A SINGLE DAY. I.E., IF THERE ARE A TOTAL OF 24 PAGES (INCLUDING FRONT AND BACK) NUMBER 1 OF 24, 2 OF 24, ETC.
  7. SAMPLE LOCATION: USE BORING OR MONITORING WELL NUMBER, GRID LOCATION (TRANSECT), SAMPLING STATION I.D., OR COORDINATE TO PHYSICAL FEATURES WITH DISTANCES. INCLUDE SKETCH IN COMMENT SECTION IF NECESSARY.
  8. SAMPLE TYPE: USE THE FOLLOWING - SOIL, WATER (SURFACE OR GROUND), AIR (FILTERS, TUBES, AMBIENT, PERSONNEL), SLUDGE, DRUM CONTENTS, OIL, VEGETATION, WIPE, SEDIMENT
  9. COMPOSITE TYPE: I.E., 24-HOUR, LIST SAMPLE NUMBERS IN COMPOSITE, SPATIAL COMPOSITE.
  10. DEPTH OF SAMPLE. GIVE UNITS. WRITE OUT UNITS SUCH AS INCHES, FEET. DON'T USE "OR"
  11. WEATHER. APPROXIMATE TEMPERATURE, SUN AND MOISTURE CONDITIONS
  12. CONTAINERS USED. LIST EACH CONTAINER TYPE AS NUMBER, VOLUME, MATERIAL (E.G., 2 - 1L GLASS, 4 - 40 ML GLASS VIAL, 1 - 400 ML PLASTIC, 1 - 3 INCH STEEL TUBE, 1 - 8 OZ. GLASS JAR)
- AMOUNT COLLECTED. VOLUME IN CONTAINERS (E.G. 1/2 FULL)

FIGURE 7-2 (CONT'D)



**Date:** \_\_\_\_\_

**Sample No.:** \_\_\_\_\_

☐ **FB:** \_\_\_\_\_

☐ DUP: \_\_\_\_\_

**Sampling Method:** \_\_\_\_\_

☐ Disposable Bailer

☐ Teflon Bailer

☐ \_\_\_\_\_  
(Other)

### Number and Types of Bottle used

☐ **Courier** \_\_\_\_\_

(Lab Name)

☐ Hand Deliver:

Well Diameter: \_\_\_\_\_

☐ 2" (0.16 Gallon/Feet)

☐ 4" (0.65 Gallon/Feet

☐ 5" (1.02 Gallon/Feet)

☐ 6" (1.47 Gallon/Feet)

80% DTW\_\_\_\_\_

[illegible]

Net Depth: \_\_\_\_\_

**Comments:**

**(Recommended Method For Purging Well)**

# CHAIN OF CUSTODY / ANALYSES REQUEST FORM

[illegible]

---

## FIELD QC SAMPLING

---

### STANDARD OPERATING PROCEDURE

---

#### **1.0 Purpose**

This Standard Operating Procedure (SOP) establishes guidelines and procedures for conducting field quality control (QC) sampling. Field QC sampling is required to assist in verifying the quality and integrity of samples collected during a given sampling event. Additional specific field QC sampling procedures and requirements will be provided in the project work plans.

#### **2.0 References**

2.1 EPA, September 1987, Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.3 SOP 1.1 - Chain-of-Custody

2.4 SOP 2.1 - Sample Handling, Packaging and Shipping

2.5 SOP 9.1 - Groundwater Sampling

2.6 SOP 17.1 - Sample Labeling

2.7 SOP 17.2 - Sample Numbering

2.8 SOP 19.1 - On-Site Sample Storage

2.9 SOP 20.1 - Sample Collection, Preservation, and Holding Times

## 2.10 SQP 4.2 - Records Management

### **3.0 Definitions**

#### **3.1 Field QC Sample**

A field QC sample is a physical sample collected during or for a specific sampling event. The purpose of this sample is to evaluate the quality and integrity of original samples collected during the specific sampling event.

### **4.0 Procedure**

This section contains both responsibilities and requirements for field QC sampling. Field QC sampling is required to provide data to verify the quality and integrity of environmental samples collected during a given sampling event.

The details within this SOP should be used in conjunction with project plans. These plans will generally provide the following information:

- Sample collection objectives
- Numbers, types and locations of environmental (non-QC) samples to be collected
- Numbers and types of supportive QC samples to be collected
- Any additional QC sampling requirements or procedures beyond those covered in this SOP, as necessary.

#### **4.1 Responsibilities**

4.1.1 The Delivery Order Project Manager is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

4.1.2 The Contractor Quality Control Manager (CQCM) is responsible for periodic review of field generated documentation associated with this SOP. The CQCM is also responsible for implementation of corrective action (i.e., retraining personnel, additional review of work

plans and SOPs, variances to QC sampling requirements, issuing nonconformances, etc.) if problems occur.

4.1.3 Field personnel assigned to environmental and QC sampling activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Site Superintendent, Delivery Order Manager, or the CQCM.

#### ***4.2 Quality Control Sampling Requirements***

4.2.1 Field QC samples may consist of different media. Typical QC samples are as follows:

- Trip blank (TB)
- Equipment rinsate (ER)
- Field blank (FB)
- Field duplicate (FD)

4.2.1.1 Trip blanks are analyte-free water, shipped from and returned unopened to the laboratory in the same shipping containers for volatile organic, and at times gasoline hydrocarbons. The blanks are prepared at the laboratory using ASTM Type II DI Water, sent to the project location, carried with the sampling team(s) during sampling, and shipped to the laboratory for analysis with the environmental samples.

Trip blank samples are commonly collected and analyzed at a rate of one per sample cooler containing samples for volatile organic analyses or the gasoline fraction of petroleum hydrocarbons. The number or rate of trip blanks to be collected and the specific analyses to be conducted for the trip blanks will be provided in the project work plans.

4.2.1.2 Equipment rinsate samples are collected from the final rinse water during decontamination of groundwater, soil, or waste sampling equipment. This type of equipment includes bailers, splitspoon samplers, soil sample sleeves, hand augering equipment, surface soil sampling equipment, purge and sample pumps, etc.

Rinsate samples are generally collected at a rate of one per day per sampling team during the sampling event. Equipment rinsates are usually collected from dedicated sampling equipment only upon installation. The number or rate of equipment rinsate samples to be collected for a particular project will be specifically developed and documented in the project work plans. The specific chemical analyses to be conducted for the rinsate samples will also be developed and documented in the project work plans.

4.2.1.3 Field blanks are prepared from the water which is used for decontamination. One sample from each sampling event and each water source or lot number is generally collected and analyzed for all parameters of interest for the project. Upon collection, a description of the water source for the field blank sample should be documented in the Sample Collection Log (Attachment 6.1)

The number or rate of field blank samples to be collected for a particular project will be specifically developed and documented in the project work plans. The specific chemical analyses to be conducted for the field blank samples will also be developed and documented in the project work plans.

4.2.1.4 For soils, field duplicate samples are generally collected by co-located sampling (e.g., using successive sample tubes from the same split spoon sampling run) or by splitting samples. Field duplicate water samples are commonly collected by retaining consecutive samples from the sampling device (e.g., bailer or sample pump discharge line). Field duplicate water samples may also be generated by splitting a collected volume; however, this practice may lead to a loss in volatile organic compounds and is not common practice for volatile analyses.

Field duplicate samples are commonly collected at a rate of 10 percent per media sampled. However, the number or rate of field duplicate samples to be collected for a particular project will be specifically developed and documented in the project work plans. The specific chemical analyses to be conducted for the field duplicates will also be developed and documented in the project work plans.

4.2.2 The type and number of QC samples collected for a particular project is based on specifications provided in project specific documents, i.e., the project work plans. Field QC samples are to be collected at appropriate times during a sampling event.

4.2.3 All field QC samples will be collected in proper containers with appropriate preservation per SOP 20.1 and the project work plans.

4.2.4 The collection of field QC samples consisting of various media (e.g., soil, groundwater, etc.) will follow procedures in sample collection SOPs for the respective media and any other applicable procedures in the project work plans. For example, the collection of a groundwater field duplicate QC sample will follow procedures specified in the groundwater sampling SOP (SOP 9.1). Equipment rinsate samples are collected directly while rinsing the sampling equipment following appropriate procedures in SOP 9.1 and the project work plans. Field blank samples are collected by pouring decontamination water directly into sample containers following appropriate protocol in SOP 9.1 and the project work plans.

4.2.5 Field QC samples will be labeled and numbered as described in SOPs 17.1 and 17.2 respectively and the project work plans.

4.2.6 The field QC samples will also be maintained under custody per SOP 1.1, and be appropriately stored, handled and shipped per SOPs 19.1 and 2.1, respectively.

## **5.0 Records**

Records generated as a result of implementation of this SOP will be controlled and maintained in the project record files in accordance with SQP 4.2.

## **6.0 Attachments**

### **6.1 Sample Collection Log**





COMMENTS:  
(Continued)

DATE

TIME

PAGE \_\_\_\_ OF \_\_\_\_

PAGE

PROJECT NO.

PREPARED BY: \_\_\_\_\_

#### LEGEND

1. A SAMPLE COLLECTION LOG IS TO BE COMPLETED FOR EACH SAMPLE.
  2. ALWAYS COMPLETE BOTH SIDES. IF SECOND SIDE IS NOT USED, DRAW A LINE THROUGH IT AND MARK N/A. FILL IN CONTROL BLOCK AND PREPARED BY.
  3. ALL ENTRIES ON LOG ARE TO BE COMPLETED. IF NOT APPLICABLE MARK N/A.
  4. DATE: USE MONTH/DAY/YEAR: I.E., 10/30/85
  5. TIME: USE 24-HOUR CLOCK: I.E., 1835 FOR 6:35 P M
  6. PAGE: EACH SAMPLE TEAM SHOULD NUMBER PAGE \_\_\_\_ OF \_\_\_\_ FOR THE DAY'S ACTIVITIES FOR ALL SHEETS PREPARED ON A SINGLE DAY. I.E., IF THERE ARE A TOTAL OF 24 PAGES (INCLUDING FRONT AND BACK) NUMBER 1 OF 24, 2 OF 24, ETC.
  7. SAMPLE LOCATION: USE BORING OR MONITORING WELL NUMBER, GRID LOCATION (TRANSECT), SAMPLING STATION I.D., OR COORDINATE TO PHYSICAL FEATURES WITH DISTANCES. INCLUDE SKETCH IN COMMENT SECTION IF NECESSARY.
  8. SAMPLE TYPE: USE THE FOLLOWING - SOIL, WATER (SURFACE OR GROUND), AIR (FILTERS, TUBES, AMBIENT, PERSONNEL), SLUDGE, DRUM CONTENTS, OIL, VEGETATION, WIPE, SEDIMENT
  9. COMPOSITE TYPE: I.E., 24-HOUR, LIST SAMPLE NUMBERS IN COMPOSITE, SPATIAL COMPOSITE.
  10. DEPTH OF SAMPLE. GIVE UNITS. WRITE OUT UNITS SUCH AS INCHES, FEET. DON'T USE " OR "
  11. WEATHER. APPROXIMATE TEMPERATURE, SUN AND MOISTURE CONDITIONS
  12. CONTAINERS USED. LIST EACH CONTAINER TYPE AS NUMBER, VOLUME, MATERIAL (E.G., 2 - 1L GLASS, 4 - 40 ML GLASS VIAL, 1 - 400 ML PLASTIC, 1 - 3 INCH STEEL TUBE, 1 - 8 OZ. GLASS JAR)
- AMOUNT COLLECTED. VOLUME IN CONTAINERS (E.G. 1 2 FULL)

FIGURE 7-2 (CONT'D)

---

## ON-SITE SAMPLE STORAGE

---

### STANDARD OPERATING PROCEDURE

---

#### **1.0 Purpose**

This Standard Operating Procedure (SOP) establishes guidelines and procedures for on-site sample storage. On-site sample storage may be required for samples collected during a given project. Additional on-site sample storage procedures and requirements will be provided in the project work plans.

#### **2.0 References**

2.1 EPA, September 1987, Compendium of Superfund Field Operations Methods, EPA 540/P-87/001a, OSWER 9355.0-14.

2.2 EPA, August 1988, EPA Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Interim Final OSWER Directive 9355.3-01.

2.3 SOP 1.1 - Chain of Custody

2.4 SOP 2.1 - Sample Handling, Packaging and Shipping

2.5 SOP 17.1 - Sample Labeling

2.6 SOP 17.2 - Sample Numbering

2.7 SOP 20.1 - Sample Collection, Preservation, and Holding Times

2.8 SQP 4.2 - Records Management

### **3.0 Definitions**

#### **3.1 Field sample**

A sample that has been collected at a project site, during the execution phase of the project, and for the purposes of the project, as defined in the project work plans.

#### **3.2 On-site**

For purposes of this SOP, "on-site" is defined as any area within the project site.

#### **3.3 On-site sample storage**

For purposes of this SOP, "on-site sample storage" applies to samples stored within the project site for a temporary period of time. Typically, samples may be stored on-site if they are in transit between the project site and a designated laboratory.

### **4.0 Procedure**

This section contains both responsibilities and requirements pertaining to on-site sample storage. Proper storage is essential to maintain the quality and integrity of samples collected during a field project.

The details within this SOP should be used in conjunction with project work plans. At a minimum, The project work plans will provide the following information:

- Sample collection objectives
- Numbers, types and locations of samples to be collected
- Any additional on-site sample storage requirements or procedures beyond those covered in this SOP, as necessary.

#### **4.1 Responsibilities**

4.1.1 The Delivery Order Manager is responsible for ensuring that all on-site sample storage activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

4.1.2 The Contractor Quality Control Manager (CQCM) is responsible for periodic review of field generated documentation associated with this SOP. The CQCM is also responsible for Implementation of corrective action (i.e., retraining personnel, additional review of work plans and SOPs, variances to sample storage requirements, issuing nonconformance, etc.) if problems occur.

4.1.3 Field personnel assigned to sample storage activities are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. All staff are responsible for reporting deviations from procedures to the Site Superintendent, Delivery Order Manager, or the CQCM.

#### ***4.2 On-Site Sample Storage Requirements***

4.2.1 Samples of all types of media may required to be stored on-site. The manner in which these samples are stored will be appropriate for individual samples or each sample type.

4.2.2 Samples collected for chemical analysis are typically required to be stored at approximately 4° Centigrade (° C). Therefore, such samples should either be preserved using water ice, and/or in a "Sample-only" refrigerator until received by the assigned laboratory. Blue ice is not recommended for on-site sample storage as it does not maintain the 4°C temperature necessary for regulatory compliance. If a refrigerator is used to store samples at the project site, this refrigerator will be dedicated for the sole use of samples; no food, drinks or other personal items will be allowed in this refrigerator.

4.2.3 Samples that do not require refrigeration (e.g. air samples and samples for geotechnical or radionuclide analysis) should be stored on-site in a designated, marked area.

4.2.4 Samples that are stored on-site must be stored in appropriate containers per SOP 20.1 and the project-specific work plans and be maintained under custody per SOP No. 1.1.

4.2.5 Samples that are stored on-site must not be stored in a manner in which they may threaten the integrity of other samples in the holding location,

4.2.6 All samples that are stored on-site must be labeled per SOP No. 17.1, numbered per SOP 17.2, and appropriately handled per SOP No. 2.1.

4.2.7 It is recommended the Site Superintendent or other designee be responsible for maintaining a master sample log listing sample numbers and a brief description of samples collected. The master log should be reviewed on a daily basis for samples that are under storage on site. The samples should then be appropriately shipped, following procedures per SOP No. 2.1, to ensure that holding time are not missed.

4.2.8 Samples that are not shipped to the assigned laboratory should be disposed of in a timely manner following appropriate disposal practices for the media from which the samples were initially obtained.

## ***5.0 Records***

Records generated as a result of implementation of this SOP will be maintained in the Project Records file in accordance with SQP No. 4.2.

## ***6.0 Attachments***

None

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## LAND SURVEYING

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### STANDARD OPERATING PROCEDURE

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#### **1.0 Purpose**

This Standard Quality Operating Procedure (SOP) describes the methods for obtaining information through field surveys, property surveys, and surveys of monitoring wells. In performing these methods, other survey requirements may need to be fulfilled (e.g., monument construction, boundary surveys). Surveying and mapping methods include plane table and alidade mapping, transit-stadia mapping, three-wire trigonometric leveling, and electronic distance measurement.

#### **2.0 References**

2.1 U.S. Coast and Geodetic Survey (1960), Hydrographic Manual, Karl B. Jeffers, U.S. Government Printing Office

2.2 SQP 4.2 - Records Management

#### **3.0 Definitions**

The location of points and orientation of lines frequently depends upon measurement of angles and directions. Directions are given by bearings and azimuths.

3.1 Azimuth - Azimuths are horizontal angles measured clockwise from any reference meridian. It is necessary to state in the field notes, at the beginning of the work, what the reference meridian is and whether azimuths are measured from north or south.

3.2 Bearing - Bearings represent one system of designating directions of lines. The bearing of a line is the acute horizontal angle between a reference meridian and the line. The angle is measured from either the north or south, toward the east or west, to give a reading less than 90°.

3.3 Bench Mark - A relatively permanent object, natural or artificial, bearing a marked point whose elevation above or below an adapted datum is known or assumed.

3.4 Second(") - One 1/60th part of a minute of angular measurement.

3.5 Project Manager - The individual responsible for the successful completion of a work assignment within budget and schedule. This person is also referred to as the Site Project Manager or Delivery Order Manager.

3.6 Third-Order Plane Survey - The required accuracy for a control survey depends on its purpose, and classification standards for accuracy have been developed by the Federal Geodetic Control Committee. There are three orders of accuracy; in descending order as first-order, second-order, and third-order. Third-order vertical control survey relative accuracy is  $2.0 \text{ mm} \times \sqrt{K}$ , where K is the distance between bench marks in kilometers. Third order horizontal central survey relative accuracy is 1 part in 10,000 (Class I) or 1 part in 5,000 (Class II).

3.7 Transit - A surveying instrument used for accurate measurement or layout of horizontal and vertical angles; determining horizontal and vertical distances by stadia, prolonging straight lines and low-order differential leveling. A transit may also be known as a theodolite.

3.8 Traverse - A traverse is a series of consecutive lines whose lengths and directions have been determined from field measurements. Traversing, the act of establishing traverse stations and making required measurements, is one of the most common means of determining the relative locations of points.

## **4.0 Procedure**

### **4.1 Responsibilities**

4.1.1 Project Manager - The Project Manager is responsible for ensuring that the surveying is properly performed. This will be accomplished through staff training or verifying the qualifications of survey subcontractors, and by maintaining quality assurance/quality control (QA/QC).

4.1.1.1 Staff Training - As a minimum, project management is responsible for seeing that the field personnel or survey team receive the following:

- Review of site specific work plans which address this procedure (e.g., SAPPs, QAPPs, QAMs, etc.).
- Review of this SOP and associated SOPs listed in this section.
- Training in the proper land surveying technique and equipment to be used.

4.1.1.2 The CQC Manager is responsible for the periodic review (daily if possible) of documentation generated by the performance of this procedure. The CQC Manager is also responsible for the performance of audit and surveillances of field personnel or survey team as they perform land surveys to assure compliance with specified procedures.

4.1.2 Field Personnel or Survey Crew - Field personnel or the Survey Team are responsible for conducting the land survey activities in accordance with acceptable industry standards and this SOP, and for the proper documentation of these activities and resulting measurements.

### **4.2 Procedures**

4.2.1 General Surveying - Survey requirements normally necessitate survey accuracies of the third order; however, the second order may be required at some sites. For the majority of sites, surveys, unless otherwise specified, will be third-order plane surveys as defined in Table 1. Work plans will specify the required accuracy for individual projects.

4.2.2 Third-order plane surveys and horizontal angular measurements should be made with a 20-second or better transit. Angles should be doubled, and the mean of the doubled angle



should be within 10 seconds of the first angle. Distance measurements will be made with a calibrated tape corrected for temperature and tension or with a calibrated electronic distance meter instrument (EDMI). When using EDM, the manufacturer's offset, curvature and refraction corrections should be applied as directed by the instrument operating instructions.

4.2.2.1 Third-Order Vertical Survey - Land surveys are to be completed by a surveyor who is licensed and registered in the state where the survey is conducted. When practical, vertical control will be referenced to the National Geodetic Vertical Datum (NGVD) of 1929, obtained from a permanent bench mark. If possible, level circuits will close on a bench mark whose elevation is known (other than the starting bench mark). If the circuit closes on the original bench mark, the last point in the circuit will be used as a turning point. The following criteria will be met when conducting the survey:

- Rod levels will be used.
- Foresight and backsight distances will be reasonably balanced.
- No side shot will be used as a turning point in any level loop.
- Elevation readings will be recorded to 0.01 foot and estimated to 0.005 foot using a calibrated rod.

4.2.2.2 Temporary monuments will be set and referenced for future recovery. All monuments will be described in the field notes and consist of a permanent mark scribed on facilities such as sidewalks, paved roads, or curbs. Sufficient description will be provided to facilitate their recovery.

4.2.3 Property Surveys - All property surveys will be performed in accordance with good land surveying practices and conform to all pertinent federal and state laws and regulations governing land surveying in the area where the work is being accomplished.

4.2.4 Upon completion of the project, all original field notebooks, computations, and pertinent reference materials will be delivered to the Project Manager for retention in the project record files. The surveyor may keep photostatic copies of the material. All field note

reductions will be checked and marked. All office entries in field notebooks will be made in a pen color different than the original.

4.2.5 Traverse Computations and Adjustments - Traverses will be closed and adjusted in the following manner:

- Bearing closures will be computed and adjusted if within limits defined in applicable work plans.
- Coordinate closures will be computed using adjusted bearings and unadjusted field distances.
- Coordinate positions will be adjusted if the traverse closes within the specified limits. The method of adjusting shall be determined by the surveyor.
- Final adjusted coordinates will be labeled as "adjusted coordinates." Field coordinates should be specifically identified as such.
- The direction and length of the unadjusted error of closure, the ratio of error over traverse length, and the method of adjustment should be printed with the final adjusted coordinates.

4.2.6 Level Circuit Computations and Adjustments - Level circuits will be closed and adjusted in the following manner:

- For a single circuit, elevations will be adjusted proportionally, provided the raw closure is within the prescribed limits for that circuit.
- In a level net where the elevation of a point is established by more than one circuit, the method of adjustment should consider the length of each circuit, the closure of each circuit, and the combined effect of all the separate circuit closures on the total net adjustment.

4.2.7 Monitoring Well Surveys - Monitoring well locations are surveyed only after the installation of the tamper proof locking cap well casing cover, which is set in concrete. The horizontal plane survey accuracy is  $\pm 1$  foot (unless greater accuracy is required) and is measured to any point on the well casing cover. The vertical plane survey must be accurate to  $\pm 0.01$  foot. Three elevations are measured, including the following:

- Top of the inner well casing (on the lip).
- Top of the outer protective casing (on the lip, not the cap).
- Survey monument on the finished concrete pad adjacent to the outer well casing.

The point on the casing where the elevation is to be measured will be scribed or notched so that water level measurements may be taken at the same location.

Note: The Project Manager should ensure that the surveying party is given the keys to the locks before starting the survey.

#### ***4.3 Hydrographic Surveys***

4.3.1 Hydrographic surveys deal with the measurement and definition of the configuration of the bottom and adjacent land areas of oceans, lakes, rivers, harbors, and other bodies of water.

4.3.2 The size of the body of water will dictate the type of survey required to perform the necessary mapping. Surveys should conform to the requirements set forth in this SOP and in the "Hydrographic Manual" by the U.S. Coast and Geodetic Survey (1960).

4.3.3 Mark sampling locations or survey points with wooden lathe stakes, wooden survey pegs or metal fenceposts. Write the location ID on the marker or survey flagging so that it is readily visible. Mark groundwater monitoring wells on the guard pipe and inside the casing cap. Use a black marker for wooden stakes, flagging, and the casing cap. Mark the guard pipes with welds or stencils and paint.

## **5.0 Records**

Records generated as a result of implementation of this SOP will be controlled and maintained in the project record files in accordance with SQP 4.2.

### **5.1 Daily Surveyors Field Log**

### **5.2 Surveyors Equipment Calibration Record**

## **6.0 Attachments**

### **6.1 Table 1, Standards for Third-Order Plane Surveys.**

## ATTACHMENT 6.1

TABLE 1

### STANDARDS FOR THIRD-ORDER PLANE SURVEYS

Principle Use:

Small engineering projects and small-scale topographic mapping.

TRAVERSE	
Number of bearing courses between azimuth checks	30 to 30 [30]*
Astronomical bearings: standard error of results	8".0 [6".0]*
Azimuth closure at azimuth checkpoint not to exceed (use the smaller value)	$30''\sqrt{N}$ or 8".0 per $[20''\sqrt{N}]^*$
Standard error of the mean for length measurements	1 in 30,000 [1 in 20,000]*
Position closure per loop in feet after azimuth adjustment	1:5,000 checkpoint or $3.34\sqrt{M}$ , whichever is smaller
Leveling	$0.05\sqrt{M}$
Levels of error of closure per loop in feet	

\*Figures in brackets are commonly used in preparing specification for bid.

N = then number of stations for carrying bearing

M = the distance in miles